Abstracts 11,662-12,242

SOLID STATE ABSTRACTS

an abstract journal devoted to the theory, production and use of solid state materials and devices

VOLUME 2 NUMBERS 7 – 8

PHYSICS

METALLURGY

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SOLID STATE ABSTRACTS

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ABSTRACTS OF THE SOLID STATE LITERATURE

METALLURGY AND CHEMISTRY OF SOLIDS

THERMODYNAMIC PROPERTIES

11,662 MIXED CRYSTAL SYSTEMS OF THE TELLURIDES AND SELENIDES OF GERMANIUM, LEAD AND TIN [in German] by K. Krebs, K. Grün, and D. Kallen (U. Bonn); Z. Anorg. Chem., Vol. 312, pp. 307-313, Nov. 1961

The mixed crystal systems SnTe-GeTe, SnTe-SnSe, PbSe-SnSe and GeTe-SnSe are described. Only in the system SnTe-GeTe does complete miscibility occur. The other systems exhibit miscibility gaps extending to about 40 mole per cent. Vegard's law is relevant to all of these systems.

11,663 RATE OF CONTACT MELTING OF METALS [in Russian] by A.V. Viatkina (Tomsk Polytech. Inst.); Izv. VUZ Fiz., No. 3, pp. 56-61, 1961

Measurements of the rate of contact melting for binary, ternary, tertiary, and five-component systems are reported. Ratios of the contact area of the crystals were varied as were the test temperature and pressure. The dependence of melting characteristics on aging time for binary, ternary, and tertiary eutectics was also studied. Values of the activation energy of the contact melting are presented. Contact melting at temperatures exceeding the contact melting temperature is related to the solubility.

11,664 CONSTRUCTION OF THE SOLIDUS LINE BY THE METHOD OF MEASURING THE MICROHARDNESS [in Russian] by V.M. Glazov (Metallurgy Inst., Moscow), Izvestiia AN SSSR, OTN, Met.i Topl., No. 4, pp. 39-42, 1961

The use of microhardness techniques to determine the solidus line by an investigation of the composition in the center of grains of nonequilibrium crystallized alloys is analyzed. The proposed method is justified experimentally in the case of the Al-Cu and Al-Si systems and it is shown that the results obtained by this means are in good agreement with the results of investigations using other methods. The equilibrium solidus line is constructed for the Bi-Sb system.

Melting and Crystallization of CdS - See 11,687

11,665 SOLID SOLUTIONS OF In_2Te_3 IN Sb_2Te_3 AND Bi_2Te_3 by A.J. Rosenberg and A.J. Strauss (Lincoln Lab.); J. Phys. Chem. Solids, Vol. 19, pp. 105-116, Apr. 1961

Solid solutions of the compositions $(Sb_2Te_3)_{1-x}(In_2Te_3)_x$, where $x \lesssim 0.45$, and $(Bi_2Te_3)_{1-x}(In_2Te_3)_x$, where $x \lesssim 0.25$, have been prepared in mono- or oligo-crystalline form by directional freezing. The crystals retain the hexagonal structure characteristic of Sb_2Te_3 and Bi_2Te_3, but in both cases the volume of the unit cell diminishes with increasing In concentration (measured spectrochemically). Density measurements and phase analysis prove that the mechanism of solid solution is either the direct replacement of Sb (or Bi) by In or the simultaneous replacement of Te by In and Sb (or Bi) by Te. The resistivity, Hall coefficient, and Seebeck coefficient have been measured. The In-substituted Sb_2Te_3 solutions are always p-type, but an inversion to n-type conductivity occurs in the Bi_2Te_3 alloys, particularly at high In concentrations. The magnitude of the Hall coefficient is virtually unchanged by the introduction of In. In the Bi_2Te_3 alloys, the carrier mobility is not strongly dependent on In content, but in the Sb_2Te_3 alloys it decreases sharply with increasing In concentration. The magnetic susceptibility is unchanged by the introduction of In. On the basis of these results, a model is proposed in which the nonbonding s-orbital of an In atom is transformed in the crystal into new states in the conduction band. Information on the phase diagram of the In-Sb-Te ternary system is included.

Distribution of As and Se in the Zone Refining of Sb - See 11,688

11,666 AN EXPERIMENTAL STUDY OF ZONE REFINING by A.F. Armington and G.H. Moates (AF Cambridge Res. Ctr.); Ultrapur. Semicon. Materials Conf., (A), Apr. 1961

Zone refining of tin and the effective distribution coefficients of In, Cu, Sb, Fe, Bi, Pb, and Co in tin were discussed. Relatively good agreement was obtained in a comparison with values cited in the literature. Effective segregation coefficients were compared with theoretical distribution coefficients derived from phase diagrams; poor agreement was obtained in more than half of the elements investigated. Analytical results were determined spectroscopically.

CRYSTAL STRUCTURE
(Including Imperfections and Impurities)

11,667 X-RAY DIFFRACTOMETER FOR AUTOMATIC OPERATION by W.A. Wooster and A.M. Wooster (Brooklyn Crystallog. Lab.); J. Sci. Instr., Vol. 38, pp. 477-479, 1961

Design of an automatically set X-ray diffractometer is discussed. Three 360-tooth worm wheels enable three axis rotation of the crystal (Furnas angles, 2θ, χ, ϕ) while two

additional wheels position the detector (Furnas angles ω, ν). Drive motors set the angles successively from a punched tape input. The obscured region resulting from full setting circles is felt to be negligible.

Effects of Temperature on the Ionic Lattice Constants of α-Sn, InSb, and CdTe - See 11,934

Etching Analysis of Quartz Imperfections - See 11,723

11,668 VACANCY SUPERSATURATION DURING QUENCHING IN Ge AND Si by J. Melngailis and S. O'Hara (Westinghouse Res. Labs.); Bull. Am. Phys. Soc., Ser. II, Vol. 6, p. 420(A), Nov. 24, 1961

The diffusion of vacancies during quenching from the melting point in Ge and Si was treated mathematically. In dendrites of 0.01-cm thickness of either material, under average conditions, approximately $10^{-3}\,\phi_0$ vacancies per cm^3 would be trapped during cooling after growth, where ϕ_0 is the equilibrium concentration at the melting point. For radiation quenched samples of larger dimensions (approximately 1 mm), the concentration trapped with surfaces acting as sinks is $1/3\,\phi_0$ to $2/3\,\phi_0$; with 6×10^4 dislocations per cm^2 acting as sinks only $10^{-4}\,\phi_0$ to $2 \times 10^{-2}\,\phi_0$ are trapped. Existing theory combined with the present calculation indicates that the formation of dislocation loops in growing dendrites of Ge is unlikely.

X-Ray Induced Color Centers in NaCl - See 11,890

11,669 ON THE RELIABILITY OF INFORMATION DEDUCED FROM DISLOCATION PATTERNS IN THIN METAL FOILS by J. Schmitz and H.G.F. Wilsdorf (Franklin Inst. Labs.); Prog. 19th Ann. Mtg. Electron Microscope Soc., p. 4(A), 1961

The changes in dislocation patterns which occur when preparing a thin foil for diffraction electron microscopy were discussed. Al single crystals with a predetermined orientation were deformed about 10 per cent in tension and subsequently thinned by an electrolytic technique. Nearly all the dislocations were intertwined and occurred as tangles, provided the specimen thickness was >1500 - 2000 A. With a specimen thickness <1000 A, the dislocations appeared as straight lines and singly. These observations were explained with the help of dislocation theory using the concepts of image forces and line energy of a dislocation.

11,670 CINE FILM OF DISLOCATION STRUCTURES AND OTHER IMPERFECTIONS IN GRAPHITE SINGLE CRYSTALS by R. Sprague (Natl. Carbon); Prog. 19th Ann. Mtg. Electron Microscope Soc., p. 4(A), 1961

Results obtained by cine photography techniques in the study of graphite single crystals were reported. A much greater feeling for the process of dislocation motion and interaction was achieved. The RCA EMU-3B viewing screen was photographed directly using a Bolex 16 mm camera and Tri-X negative film. In this film crystal step edges are seen to act as sources for dislocation motion and grain boundaries as dislocation sinks. The motion of a decorant $FeCl_3$ also is observed and influenced by the electron beam.

11,671 DISLOCATION SUBSTRUCTURES IN DEFORMED AND RECOVERED MOLYBDENUM by R. Benson and G. Thomas (Lawrence Rad. Lab., U. California); Prog. 19th Ann. Mtg. Electron Microscope Soc., p. 4(A), 1961

By the use of experimental observations, a heuristic analysis for strain hardening and recovery in bcc metals was developed. Foils prepared from bulk polycrystalline Mo by electropolishing were examined in a Hitachi H.U. 10 electron microscope. The dislocation structure was observed as a function of annealing temperature for a constant annealing time and constant prestrain. At strains of 1 - 3 per cent, many dislocation nodes, straight dislocation segments, and jogged dislocations were observed. At least two slip systems operate even at the lowest strains and, by interactions of the type

$$\frac{a}{2}(11\bar{1}) + \frac{a}{2}(1\bar{1}1) \rightarrow a(100),$$

relatively immobile <100> segments are formed. At macroscopic strains of about 3 - 5 per cent a cell develops which consists of very dense subboundaries of dislocations. The results are discussed in terms of the relationship between dislocation substructure, flow stress, and recovery.

11,672 DISLOCATIONS IN CRYSTALS OF IRON-SILICON ALLOYS INDENTED BY A BALL by B. Sestak and S. Libovicky (Czech. Acad. Sci., Prague); Czech. J. Phys., Vol. 11B, pp. 444-451, 1961

The slip band structure within the area deformed by the indentation of a steel ball and the surface etching of the Fe-Si alloys used to render such dislocations visible are discussed. The shape of the slip surfaces is examined and the dimensions of the deformed area are determined as a function of the Si content, of the temperature and of the deformation speed. The observed slip is microphysically explained assuming that parts of the screw dislocations, if moving, show a cross-slip.

11,673 PHONON VISCOSITY AND ITS EFFECT ON ACOUSTIC WAVE ATTENUATION AND DISLOCATION MOTION by W.P. Mason (Bell Labs.); J. Acoust. Soc. Am., Vol. 32, pp. 458-472, Apr. 1960

Phonon viscosity and its effect on acoustic wave attenuation and dislocation motion are discussed. The flow of heat between the hot and cold phonons (those lying in the compressed or extended direction of the associated shear wave) produces a damping of the sound wave corresponding to a viscosity $\eta = E_0 K/C_v \nabla^2$ as long as the time of application of the shear wave is long compared to τ. When the product $\omega\tau >> 1$, this source of loss disappears. Phonon viscosity contributes directly to the acoustic attenuation. By using thermal and sound velocity measurements to evaluate the viscosity, it is shown that available data on the attenuation of sound in metals and nonconducting crystals are in agreement with the calculated values of dislocation damping by phonon viscosity. A direct check for both edge and screw dislocation is obtained from recent work on the velocity of dislocations in LiF.

11,674 ON THE PROBLEM OF LARGE ANGLE GRAIN BOUNDARIES. Part II. [in Czech] by E. F. Hollander (Czech. Akad. Nauk); Czech. J. Phys., Vol. 11B, p. 290(A), 1961

The variation of the width of dislocations forming a tilt grain boundary with their mutual distance is derived using a simple model. The derived relation is compared with the variation of the dislocation core radius with distance assumed in the derivation of the corrected Shockley-Read formula.

11,675 TWINS AND DISLOCATIONS IN SILICON MONOCRYSTALS by M.G. Mil'vidskii and L.V. Lainer; Soviet Phys.-Solid State, Vol. 3, pp. 210-214, July 1961

Studies of the external forms of twins in silicon monocrystals grown from the melt using the Czochralski method, and the behavior of the dislocations in monocrystals with twins are reported. Experimental results are presented in detail. It is observed that the twin boundaries form barriers to the motion of dislocations into the twinned parts of the crystals and that the dislocations in slip lines can be forced through a twin boundary. The results show that the density of dislocations in a twin depends upon two main factors: (a) the density of dislocations which penetrate the twin boundary traveling from the original crystal; (b) the change produced by twinning in the orientation of slip systems with respect to the temperature gradient in a growing crystal.

11,676 THE STRUCTURE OF GRAPHITE by T. Anno and C.A. Coulson (Oxford U.); Proc. Royal Soc., Vol. 264, pp. 165-175, Nov. 7, 1961

An investigation of the stability of a graphite layer considering the several possible types of deformation is reported. In the first (type I) mode of deformation lengths of all three bonds starting from any atom in the layer are different. The transitional symmetry of the hexagonal configuration within the layer is maintained. In type II, alternate hexagons remain regular but the lengths of the bonds joining them differ. Two types were found within this category, distinguished as IIA and IIB. No account of interaction between layers is taken. The calculation is based on the Hückel version of the molecular-orbital method for the π electrons, with inclusion of an energy term representing the compression of the σ-bonds. All three types of deformation, with reasonable numerical values for the parameters, correspond to an absolute minimum of the total energy with respect to these modes of deformation in the regular configuration usually adapted.

11,677 EQUILIBRIUM CONCENTRATION OF IMPURITIES IN A SEMICONDUCTOR ADJACENT TO A GAS PHASE FROM THERMODYNAMIC DATA by K. Lehovec (Sprague Elect.); Bull. Am. Phys. Soc., Ser. II, Vol. 6, p. 302(A), Apr. 24, 1961

Calculations of the equilibrium concentration of impurities using vapor pressure data and the phase diagram of the binary system semiconductor-impurity metal were described. The calculations are based on a thermodynamic cycle involving the impurities (a) in the semiconductor, (b) in the gas phase outside the semiconductor, (c) in the gas phase above the liquidus of the impurity metal-semiconductor binary system, (d) in the liquidus, and (e) in the semiconductor in equilibrium with the liquidus. Since the vapor pressure of impurities adjacent to the semiconductor at the diffusion temperature is usually smaller than that pertaining to the liquidus, it is necessary to dilute the liquidus in a metal experiment to obtain the appropriate vapor pressure. However, this dilution must be done without affecting the binary system metal-semiconductor, e.g., by considering a liquidus containing two impurity isotopes, one of which has a partial vapor pressure equal to the impurity vapor pressure adjacent to the semiconductor. Vapor pressure data pertaining to the liquidus line do not seem available to test these results. Experimental work to obtain pertinent data is in progress.

11,678 SPACE-CHARGE CURRENT MEASUREMENT AS A TECHNIQUE FOR THE DETECTION OF TRACE IMPURITIES IN ULTRAPURE MATERIALS by R.W. Smith (RCA Labs.); Ultrapur. Semicon. Materials Conf., (A), Apr. 1961

A simple dc electrical method for detecting extremely minute quantities of impurities in ultrapure insulating crystals was described. The technique is based on measurement of the steady space-charge-limited current flowing through a thin section of insulator when a voltage is applied across the crystal via ohmic contacts. Most of the injected space charge is held immobilized in localized defect states in the crystal, energetically located in the forbidden gap between the conduction and valence band extrema. A very small, but significant, fraction of the space charge remains in the conduction band, free to contribute to the steady-state current. As the steady-state Fermi level (the steady-state analog of the thermodynamic Fermi level) moves through a discrete defect level or a distribution of defect levels, the observed current varies steeply with applied voltage. In such a voltage range of steep current variation, the elementary electrostatic relationship $Q = CV$ (Q = total injected charge, C = capacitance between anode and cathode), gives directly a measure of the total defect density lying between the steady-state and thermal equilibrium positions of the Fermi level in the forbidden gap. By such measurements discrete levels of density $\sim 10^{14}$ per cc and located 0.8 ev below the conduction band have been observed in high purity CdS. This determination illustrates the practicability of this method of trace analysis. An unusual characteristic of the space-charge current technique is that the measurements become easier the purer the materials, down to total impurity densities as low as 10^6 per cc.

11,679 TRACE ANALYSIS IN SEMICONDUCTOR CRYSTALS BY X-RAY DIFFRACTION MICROSCOPY by G.H. Schwuttke (Genl. Tel. Electronics); Ultrapur. Semicon. Materials Conf., (A), Apr. 1961

Analysis of dislocation structures by X-ray diffraction microscopy was discussed and its application in the detection of minute impurities in the semiconductor lattice was described. The visibility of dislocations is determined chiefly by the angle between the Burger's vector and the Bragg reflecting plane. When the Burger's vector lies in the Bragg reflecting plane, the dislocations are either invisible or have very low visibility. Impurities are known to migrate to dislocations and precipitate along dislocation lines. These precipitates enhance the visibility of dislocations in the diffraction image; such contrast changes can be used to detect minute impurities. The detection of microsegregation, cluster formation, and random precipitation was also discussed.

11,680 POLAROGRAPHIC AND COLORIMETRIC DETERMINATION OF SELENIUM IN GALLIUM ARSENIDE by E.H. Cornish and E.L. Bush (Stand. Telecommun. Labs.); Ultrapur. Semicon. Materials Conf., (A), Apr. 1961

A colorimetric and a polarographic method developed for the determination of trace quantities of selenium in gallium, arsenic and gallium arsenide were described. Agreement between the two methods is fairly good.

11,681 DETERMINATION OF SUBMICROGRAM QUANTITIES OF BORON IN HIGH PURITY ELEMENTAL SILICON by J. Roesmer (Nuc. Sci. and Engrg.); Ultrapur. Semicon. Materials Conf., (A), Apr. 1961

An activation analysis technique for the determination of boron in transistor grade Si in the parts per billion range was described. The reaction $B^{11}(n,\gamma)B^{12}$ was rejected because of the rather short half-life of B^{12}. The reactions $B^{10}(d, n)C^{11}$

were considered to be of potential analytical value. Irradiations by both 7 Mev protons and 7 Mev deuterons were undertaken during this study. Because of the unexpected large amount of nitrogen in the Si samples, the proton irradiations were not successful in determining the boron concentration. The C^{11} produced by the reaction $N^{14}(p, \alpha) C^{11}$ was much greater than that produced by the desired boron reaction. In the deuteron irradiations, however, the yield of the boron reaction is much greater than the yield from the nitrogen reaction $N^{14}(d, n\alpha) C^{11}$, and the boron could be measured. Suggestions for modification in target arrangement, counting and chemical procedures, which may substantially improve the sensitivity of the method were given.

11,682 ELECTRICAL AND MASS SPECTROGRAPHIC ANALYSIS OF III-V COMPOUNDS by R.K. Willardson (Bell and Howell); Ultrapur. Semicon. Materials Conf., (A), Apr. 1961

Analysis of impurities in III-V compounds was discussed. Majority and minority impurity concentrations determined from the temperature dependence of the Hall coefficient, magnetoresistance, and Hall mobility were compared with mass spectrographic data over a range of impurity concentrations between 1 and 10,000 parts per billion. The samples ranged from nearly uncompensated to those containing nearly equal numbers of p- and n-type impurities. Special emphasis was given to the determination of C^{12}, Si^{28}, and O^{16} and their effect on carrier generation and scattering phenomena. In GaAs with an electron mobility of 5000 cm^2/volt-sec and a carrier concentration of $2 \times 10^{17}/cm^3$, the major impurity was found to be 6 ppm Si. In higher purity GaAs with an electron mobility of 6000 cm^2/volt-sec and a carrier concentration of $2 \times 10^{16}/cm^3$, the Si content of 0.6 ppm could account for the carrier concentration but not the mobility. Other impurities such as 0.1 ppm oxygen and 0.1 ppm carbon appear to have a significant effect on the electron mobility. Sulphur was found to be of negligible importance in most of the GaAs and InAs studied, being less than 30 ppb. The effects of ion clusters, multiple ionization, and residual gas background on the mass spectrographic analysis were discussed.

11,683 THE APPLICATION OF SOLID-SOURCE MASS SPECTROMETRY TO DETERMINE THE PURITY OF MATERIALS FOR SEMICONDUCTOR PURPOSES by J.F. Duke (Natl. Phys. Lab., Teddington); Ultrapur. Semicon. Materials Conf., (A), Apr. 1961

The use of an A.E.I. M.S. 7 solid-source mass spectrometer to analyze pure metals was discussed. The sensitivity of the instrument is such that impurity concentrations as low as 1 part in 10^9 atomic can be detected. Almost the whole of the periodic table can be covered in a single analysis. Some selected applications were described and details of the initial operating experiences were given.

11,684 ANALYSIS OF TRACE IMPURITIES BY SPARK SOURCE MASS SPECTROMETRY by R. Brown, R.D. Craig, J.A. James, and C.M. Wilson (Assoc. Electrical Ind.); Ultrapur. Semicon. Materials Conf., (A), Apr. 1961

Spark source mass spectrometric analysis of pure metals was discussed. (See Abstract 11,683 for a brief description of the instrument used.)

Zone Refining of Sn - See 11,666

11,685 PREPARATION OF HIGH-PURITY SILICON FROM SILANE by C.H. Lewis, H.C. Kelly, M.B. Giusto, and S. Johnson (Metal Hydrides); J. Electrochem. Soc., Vol. 108, pp. 1114-1118, Dec. 1961

An investigation of the preparation, purification, and thermal decomposition of silane, SiH_4, for the purpose of preparing high-purity Si is discussed. Quantitative yields of SiH_4 were obtained by the reduction of $SiCl_4$ with lithium aluminum hydride. Variables in the thermal decomposition of SiH_4 were evaluated with regard to purity of the elemental Si produced and the efficiency of dissociation and deposition rate. SiH_4 was dissociated on an inductively heated single crystal Si substrate to yield high-purity Si. Neutron activation analyses for microcrystalline high-purity Si as deposited are given.

11,686 METHOD OF PURIFYING SILICON CARBIDE by K. M. Hergenrother (Transitron); U.S. Pat. 2,996,415, Issued Aug. 15, 1961

A method for removing metallic impurities, especially aluminum, from silicon carbide is described. The silicon carbide is dissolved in a melt of chromium containing oxygen, preferably as an oxide of chromium, and a crystal is grown from the melt. The oxygen reacts with the aluminum at the temperature of the melt-crystal interface and forms an oxide with a high heat of formation, thus removing the aluminum from the silicon carbide. The chromium also removes traces of silicon or carbon impurities in the silicon carbide. Other impurities such as zirconium and titanium can also be removed by forming an oxide with a high heat of formation. Junctions can be formed by controlling the amount of oxygen in the chromium.

11,687 RESEARCH IN PURIFICATION OF CADMIUM SULFIDE CRYSTALS by R.H. Fahrig, K.E. Bean, et al. (Eagle-Picher); U.S. Gov. Res. Rep., Vol. 36, p. 109(A), Sept. 20, 1961 AD 259 883

The purification of Cd and S and the subsequent synthesis of spectrographically pure CdS from the refined elements are described. The growth of large crystals of CdS by the method of vapor phase deposition is discussed. Modifications of apparatus and method are described and illustrated. The results of studies concerning raw materials, sintering, doping, diffusion and heat treating are given. A section dealing with the melting and crystallization of cadmium sulfide and other materials in a pressure melting furnace is presented. The testing and evaluation of cadmium sulfide crystals suitable for solar cells are described.

11,688 DISTRIBUTION OF ARSENIC AND SELENIUM IMPURITIES IN THE ZONE REFINING OF ANTIMONY [in Russian] by V.N. Vigdorovich, V.S. Ivleva, and L. Ia. Krol' (USSR Acad. Sci.); Izv. AN SSR, OTN, Met. i Topl., No. 4, pp. 29-30, 1961

The behavior of As and Se impurities in Sb during zone refining is considered and an explanation of the influence of the initial concentration on the efficiency of their removal during refining is presented. Both the impurities studied have a constant distribution coefficient in the $10^{-1} - 10^{-4}$ per cent range of concentrations.

Formulation of Diffusion Equations - See 11,774

11,689 HORIZONTAL INDUCTION ZONE MELTING OF REFRACTORY METALS AND SEMICONDUCTOR MATERIALS

by A. Berghezan and E.B. Simonsen (European Res. Assoc., Belgium); AIME Trans., Vol. 221, pp. 1029-1031, Oct. 1961

A simple and general method for melting and zone refining refractory metals by induction heating on a specially shaped water-cooled Cu crucible is described. The crucible is the essential part of the apparatus and is placed horizontally. It consists of either a copper plate, a flattened tube, or one of several parallel small diameter tubes that are all water cooled. The charge lies on the crucible or is suspended above it. This assembly goes into a transparent quartz tube and the whole is passed through the coil of a radio frequency generator. Various atmospheres can be used. No contamination is detected from the Cu crucible. Purification is obtained both by selective evaporation of impurities and by zone refining.

11,690 ON THE DETERMINATION OF THE CONCENTRATION PROFILE OF DIFFUSION LAYERS IN SILICON FROM LAYER CONDUCTIVITY MEASUREMENTS [in German] by G. Ksall (Inst. Hableitertech., Teltow); Phys. Status Solidi, Vol. 1, pp. 181-188, 1961

A method of evaluating measurements of sheet resistivity with a four point probe is described. The determination of the concentration profile of diffused layers is possible without special assumptions concerning the concentration distribution. Experimental examinations of diffused p-type layers on n-type silicon in the vicinity of the junction result in considerable deviations of the measured distribution from the exponential function and the complementary error function.

11,691 PREPARATION OF ALLOYED MONOCRYSTALS AND P-N JUNCTIONS IN ALUMINUM ANTIMONIDE by M.S. Mirgalovskaya and I.A. Strel'nikova (Baikov Inst. Metall., USSR); Soviet Phys.-Solid State, Vol. 3, pp. 332-334, Aug. 1961

The effect of Te, Se, and S impurities on AlSb and on the properties of p-n junctions in this compound is studied. Monocrystals of AlSb were grown from a melt; they were p-type and contained less than 0.001 per cent each of Mg, Si, Cu, and Fe impurities. The Te, Se, and S impurities were introduced into the melt in various proportions. It was found that p-type conduction was altered to n-type on the introduction of 0.05 per cent Te, 0.07 per cent Se or 0.09 per cent S. Addition of Se in amounts from 0.07 to 0.09 per cent produced p-n junctions, the addition being accomplished after one-third of the crystal was grown. Best results were obtained at 0.09 per cent Se.

Growth Spiral Structure of Synthetic Diamond - See 11,692

Crystal Structure of In-Sb-Te and In-Bi-Te Solid Solutions - See 11,665

CRYSTAL GROWTH

11,692 A NOTABLE GROWTH SPIRAL ON SYNTHETIC DIAMOND by S. Tolansky (U. London); Nature, Vol. 190, p. 992(L), June 10, 1961

An example of single growth spiral on synthetic diamond is described. This is a rare phenomenon in diamond, occurring in only a few out of several thousand faces examined. Microcrystal diamonds were examined with a high-sensitive phase-contact microscope and with two-beam interferometry. The growth spiral appears on an incompleted cubic face and has a step-height of about 1300 A. The technique used is capable of revealing step-edges as low as 2.5 A.

Growth of InSb - See 11,697

11,693 THE TECHNOLOGY OF PULLING SINGLE CRYSTALS. Part II. by H.T. Minden (GE); Semicon. Prod., Vol. 4, pp. 28-34, Dec. 1961

Possible pitfalls in the design, construction and operation of a crystal puller are pointed out. Many defects in puller design can be quickly detected and analyzed if the operator is provided a clear view of the liquid-crystal junction. Ingots sometimes become polycrystalline if they grow beyond a certain diameter. To maintain a symmetrical temperature profile, the crucible should be rotated within the heater. The use of a graphite crucible with induction heating yields the thermal configuration of a resistance heater. The technological artifacts causing imperfect crystal growth are pointed out. Some of the basic problems of growing compound semiconductors are discussed and a few technical details are given. GaAs is used as an example. The technology basic to the Czochralski crystal pulling technique is stressed and other techniques are mentioned.

11,694 A COLD CRUCIBLE FOR HIGH-TEMPERATURE MELTING PROCESSES by H.F. Sterling and R.W. Warren (Stand. Telecommun. Labs.); Nature, Vol. 192, p. 745(L), Nov. 25, 1961

The growth of oxygen- and dislocation-free Si single crystals from cooled Ag crucibles by the Czochralski method is discussed. One crucible consists of a number of tapered, water-cooled Ag tubes which are arranged vertically and which curve inward at the bottom. The narrow ends of the tubes are joined at the bottom to form a basket. The crucible is water-cooled internally and is mounted inside a radio frequency primary coil. Power is induced through the spaces between the tubes and by induction due to current which flows circumferentially in each tube. The melting of the Si is complete and the tubes are placed sufficiently close together to prevent the melt from escaping. Lifetimes up to 1 msec and resistivities greater than 1000 ohm-cm have been measured in crystals grown from silicon obtained by the thermal decomposition of pure SiH_4. Electrical and radiochemical tests have not detected the presence of Ag in these crystals. The cold metal crucible has also been used as a noncontaminating container for melting and processing such materials as ferrites, rare earth metals, Mo, and boron.

11,695 THE ROLE OF CONTAMINATION IN GaAs CRYSTAL GROWTH by L. Ekstrom and L.R. Weisberg (RCA Labs.); Ultrapur. Semicon. Materials Conf., (A), Apr. 1961

Causes of contamination of GaAs were discussed. Cu impurities may be introduced into Ga by a vacuum bake at 650°C. Back diffusion of impurities from contaminated vacuum pumps was observed even at pressures of 10^{-6} mm Hg. Quartz ampoules sealed under vacuum contaminated As gas when the quartz was heated at 1000°C. No diffusion of atmospheric gases through quartz was observed but 10^{18} molecules of gas were released from the walls due to outgassing. Serious contamination by Si and Mg occurs due to reactions between the GaAs melt and the quartz boat. This contamination is almost

negligible at the melting point but increases upon heating 20°C above the melting point.

11,696 IMPURITY DISTRIBUTION IN SINGLE CRYSTAL INDIUM ANTIMONIDE by G.R. Cronin (Texas Instr.); J. Electrochem. Soc., Vol. 33, p. 178C(A), Aug. 1961

An investigation of the anistropic segregation of various impurities in InSb was discussed. Crystals oriented (111), (110), (311), and (100) were pulled from melts containing radioactive Zn, Sn, Fe, and Ag. Uniformity of distribution was evaluated parallel and perpendicular to the growth direction. The most striking result was the nonuniformity of (111) crystals compared with other orientations. All of the results were explained in terms of the facet effect.

11,697 DISTRIBUTION OF SULFUR IMPURITY IN InSb SINGLE CRYSTALS by M.D. Banus and H.C. Gatos (Lincoln Lab.); J. Electrochem. Soc., Vol. 108, p. 178C(A), Aug. 1961

Studies of the distribution of sulfur in single crystals of InSb doped with inert or radioactive sulfur (S 35), pulled from the melt using a Czochralski-type technique, were presented. High resolution autoradiography and electrical measurement techniques were employed. In crystals grown along the (111) direction, a well-defined core with increased concentration of sulfur is associated with the (111) facet present at the liquid solid interface. The effects of changing rotation rate during growth on the concentration "on facet" and "off facet" and on the effective distribution coefficients were presented. The results were discussed on the basis of crystal growth mechanisms.

11,698 HIGHLY ORIENTED BORON NITRIDE by D. Belforti, S. Blum, and B. Bovarnick (Raytheon); Nature, Vol. 190, p. 901(L), June 3, 1961

The structure of boron nitride prepared by vapor phase pyrolysis and deposition on a hot target is described. Using boron-bearing gases and regulating the parameters of the treatment, the deposit can be controlled. The X-ray diffraction pattern shows the deposit to be composed of highly-oriented crystallites parallel to the deposition surface. The dimensions of a unit cell were measured, and the density was 2.26 gm/cm^3 as against 2.27 gm/cm^3 for normal boron nitride. Observed impurities were Mg, Mo, and Si at levels of 10 ppm or less. One-half mm pieces were translucent and white or yellow; the microstructure shows columnar cones similar to those of pyrolytic graphite. The technique of pyrolytic preparation produces samples with highly oriented structures which may be used in place of single crystals for investigating some properties of materials.

11,699 METHOD OF GROWING SILICON CARBIDE CRYSTALS by K.M. Hergenrother (Transitron); U.S. Pat. 2,996,456, Issued Aug. 15, 1961

The growth of silicon carbide crystals from a melt consisting of silicon carbide dissolved in a solvent such as silicon or chromium is discussed. The crystal may be grown by pulling a silicon carbide seed from the melt or by passing a molten solvent zone through a crystal. In the latter case a sandwich consisting of a layer of silicon carbide, a layer of chromium, and another layer of silicon carbide is formed and a temperature gradient is applied across the sandwich. The chromium melts and the gradient causes the molten layer to pass through the hotter semiconductor. Silicon carbide crystals are grown on the unmelted layer as the molten zone passes through the sandwich. If both SiC layers are p-type and the molten zone is chromium, the regrown layer is n-type. If both layers are n-type and the chromium is doped with boron, the regrown layer is p-type.

11,700 THE TRAVELING SOLVENT METHOD OF CRYSTAL GROWTH by A.I. Mlavsky (Tyco); J. Electrochem. Soc., Vol. 108, p. 263C(A), Dec. 1961

A technique for the growth of single crystals of intermetallic compounds from solution was described. The technique involves the passage of a thin solvent zone through a material under the influence of a temperature gradient which may be produced by the Peltier effect. This technique is particularly applicable to high melting point compounds or compounds having a volatile component. It also can be adapted to the fabrication of junction structures. Some preliminary results for the growth of GaAs on Ga were given.

11,701 CONTINUOUS CASTING OF THERMOELECTRIC MATERIALS by R.J. Hach, M.J. Brau, and T.S. Burkhalter (Texas Instr.); Rev. Sci. Instr., Vol. 32, pp. 1341-1343, Dec. 1961

A casting device for rods of alloys of Bi_2Te_3, Sb_2Te_3, and Bi_2Se_3 with less than five per cent deviation of the thermoelectric properties over the length of the rod is described. A graphite crucible containing the continuously stirred melt is placed in a pressurized oven. The melt passes through a hole in the bottom of the crucible and through a precision boron carbide die where it freezes and is drawn by an external lead screw.

Vapor Growth of Intermetallic Compounds - See 11,947

Vapor Phase Growth of Cds - See 11,687

11,702 VAPOR GROWTH OF GaAs by V.J. Lyons and V.J. Silvestri (IBM); J. Electrochem. Soc., Vol. 108, p. 177C(A), Aug. 1961

The growth of single crystal films of GaAs from a vapor phase consisting of Ga iodides and As was described. This work followed from the fact that synthesis and crystal growth of III-V compounds can be carried out at temperatures below the compound melting points by reacting a Group III halide with a Group V element. The growth material was deposited epitaxially on monocrystalline GaAs of various crystallographic orientations. The reactions were carried out in sealed quartz tubes under varying conditions of temperature and pressure. Measurements of the resistivity and mobility of the deposited GaAs were presented. Vapor pressure measurements for the system were discussed.

11,703 VAPOR GROWTH OF GALLIUM ARSENIDE by R.L. Newman (Penn. State) and N. Goldsmith (RCA); J. Electrochem. Soc., Vol. 108, pp. 1127-1130, Dec. 1961

The growth of epitaxial layers of GaAs on a GaAs substrate from the vapor is discussed. An open system is used, with a chloride as the transporting agent. The GaAs is transported from a hot region (~1000°C) to a cooler region (~900°C). Layers up to 6-7 mils in thickness have been grown. The interfaces between substrate and growth are quite good. Substrate orientation appears to be critical, controlling both amount of growth and crystalline perfection of the deposit. Some electrical properties of the junctions formed are discussed.

11,704 A MULTISLICE TECHNIQUE FOR EPITAXIAL GROWTH OF SILICON LAYERS by V. Sils, J. Porter, N. Cerniglia, and P. Wang (Sylvania); J. Electrochem. Soc., Vol. 108, p. 262C(A), Dec. 1961

A multislice production-scale process for the epitaxial growth of Si layers for mesa transistors in an induction-heated vertical furnace was described. Tight control of layer thickness, surface finish uniformity, and layer resistivity has been achieved. The collector breakdown voltage of transistors made from the epitaxial wafers can be controlled in tight limits. Techniques for checking layer resistivity and layer thickness were discussed.

11,705 SOME PROPERTIES OF EPITAXIAL GERMANIUM by A.B. Kuper and H.Christensen (Bell Labs.); J. Electrochem. Soc., Vol. 108, p. 177C(A), Aug. 1961

Investigations of germanium (111) epitaxial films, deposited in an open tube system from H_2-GeCl (undoped) at 850°C, were discussed. Junction capacitance measurements suggested that the principal impurity is Cu (2.5×10^{14}/cc after 600°C anneal). After etch removal of the substrate one of these films was annealed at 550°C. Sheet resistance measurements as a function of annealing time suggested slow precipitation of copper characteristics of Ge with less than 10^3 dislocations/cm^2. Hall effect hole mobility vs temperature was similar to that in high resistivity melt-grown Ge. Electron transmission diffraction showed no crystalline imperfections in these films.

11,706 PERFECTION OF EPITAXIAL AND DIFFUSED LAYERS by G.H. Schwuttke (Genl. Tel. Electronics); J. Electrochem. Soc., Vol. 108, p. 262C(A), Dec. 1961

An investigation of crystal perfection in thin epitaxial layers on Si by X-ray diffraction microscopy was reported. It was found that the dislocation densities in the base material and layer can be quite different from each other. Defects present on the surface of the base material were shown to act as dislocation sources during the growth of the epitaxial layer. The method was also employed to study the perfection of shallow diffused surface layers. Here it was used to analyze the nature of regular arrays of lines as observed by Queisser and Prussin. It was established that these lines are dislocations lying in the diffusion plane and are introduced by the diffusion process.

11,707 SURFACE EFFECTS AND AUTODOPING IN EPITAXIAL GERMANIUM LAYERS by E. Matovich and R.J. Andres (Hughes Prod.); J. Electrochem. Soc., Vol. 108, p. 177C(A), Aug. 1961

The growth of high-resistivity epitaxial Ge by use of a catalytic reduction of GeCl in an open-tube process was described. The temperatures were intermediate to those used for pyrolytic decomposition of $GeCl_4$ (Bell Labs.) and disproportionation of GeI_2 (IBM). Surface structure of and impurity distribution in the epitaxial layers were shown to be a function of the growth conditions.

11,708 OBTAINING REPLICA FROM THE TRANSVERSE CROSS SECTION OF THIN FILMS by R. Ya. Berlaga and M.I. Rudenok (Leningrad State U.); Soviet Phys.-Solid State, Vol. 3, pp. 458-459, July 1961

A method of making photographs of transverse cross sections of thin films without using a microtome is described. A film of PbS to be observed is deposited by means of vacuum evaporation onto a glass substrate. The substrate is then ruptured and in succession a very thin layer of Al (100 - 200 A) and a carbon film are vacuum evaporated onto the rupture. The carbon layer coats both the rupture and the surface adjacent to it. HCl is then used to dissolve the Al, freeing the C film which is then scanned on an electron microscope. This allows the simultaneous viewing of the film surface and cross section. Some results are given for PbS films before and after heat treatment.

11,709 INTERFERENCE METHOD FOR MEASURING THE THICKNESS OF EPITAXIALLY GROWN FILMS by W.G. Spitzer and M. Tanenbaum (Bell Labs.); J. Appl. Phys., Vol. 32, pp. 744-745(L), Apr. 1961

Observations on the thickness of thin lightly doped epitaxial layers deposited on heavily doped substrates of the same semiconductor determined by interference fringes produced by infrared radiation reflected from the surface of the epitaxial layer and from the interface between the layer and the substrate are discussed. The interference method can be used because at sufficiently large carrier concentrations the dielectric constant of semiconductors in the infrared is a function of the carrier concentrations. Measurements made on layers deposited on p-type Si and Ge are discussed. In the case of Si, the interference method gave a thickness of $7.6 \pm 0.3\mu$ while the lapping and staining method gave a value of 7.3μ. No comparative measurements were made in the germanium sample since the staining technique could not clearly delineate the junction. The lower limit on the layer thickness which can be measured by the interference technique depends on the particular semiconductor.

11,710 EPITAXIAL SILICON-GERMANIUM ALLOY FILMS ON SILICON SUBSTRATES by K.J. Miller and M.J. Grieco (Bell Labs.); J. Electrochem. Soc., Vol. 108, p. 262C(A), Dec. 1961

Some properties of Si-Ge alloy films grown epitaxially on (100), (110), and (111) Si substrates over a composition range of up to 30 atomic per cent Ge were discussed. The apparatus and method used to grow these films were described.

11,711 SURFACE STRUCTURE OF DENDRITIC GROWTH OF GERMANIUM by V.G. Bhide and V.M. Chandratreya (Inst. of Sci., Bombay); Ultrapur. Semicon. Materials Conf., (A), Apr. 1961

The growth of Ge dendrites from an undercooled melt by suddenly reducing the temperature of the melt by about 10° to 20°C below the melting point was described. Rapid crystal growth is enforced and proceeds from the watercooled seed into the melt as the temperature attains its new equilibrium value. The seed is withdrawn and if it is properly oriented, e.g., with the (111) plane vertical, the essentially flat plate is found on it. If the speed of the withdrawal is properly adjusted, the lamella grows indefinitely in length, limited only by the dimensions of the apparatus. These crystals were examined employing phase contrast microscopy and multiple beam interferometry. A number of interesting surface features have been observed on these crystals that indicate the existence of a twin plane as a core of a dendrite. Twins may be even or odd; this determines the orientation of growth features on the obverse and reverse faces of the dendrite. Etching experiments further confirm the existence of a twin plane as the core of a dendrite. The tip of the dendrite was found to offer a favorable spot for nucleation as well as initiation of growth layers.

11,712 VAPOR PHASE GROWTH OF GALLIUM ARSENIDE CRYSTALS by W.J. McAleer, H.R. Barkemeyer, and P.I. Pollak (Merck); J. Electrochem. Soc., Vol. 108, pp. 1168-1169(L), Dec. 1961

The vapor phase growth of large bladelike crystals of GaAs in systems containing the semiconductor compound components and a transfer agent such as I with a temperature gradient is discussed. The crystals were grown under conditions which permitted the reproducible production of a specific crystal habit. Crystals up to 10 cm long, 0.5 cm wide, and 0.01 cm thick have been grown. Radiotracer measurements have revealed I concentrations of 0.11 per cent at the surface and 0.024 per cent at the interior of the crystals. The crystals were n-type; p-type crystals doped with Zn have been prepared by similar methods. The etching behavior of the crystals is characteristic of (111) and ($\overline{111}$) faces in III-V compounds with the zincblende structure.

11,713 A SIMPLE TECHNIQUE FOR GROWING SEEDED SINGLE-CRYSTAL ANTIMONY SQUARE-SECTIONED RODS by S. Epstein (USASRDL); J. Electrochem. Soc., Vol. 108, p. 264C(A), Dec. 1961

The growth of single crystal square (3 x 3 mm) antimony rods by a modification of the apparatus and procedures utilized to grow various shaped unstrained single crystal rods of bismuth and higher melting point elements was discussed. Unstrained single crystal rods 6 cm or more in length with axes at either 0°, 45°, or 90° with the principal crystallographic axis have been grown. The direction of growth is the rod axis and, by the use of both a fast crystallization rate and a crucible material of low thermal conductivity, growth normal to the preferred direction (which is the case for the 0° rods) was accomplished. Secondary axis orientation also is conveniently controlled by the apparatus and procedure. A measure of rod quality for two principal orientations was indicated.

Growth of Mg_2Sn - See 11,933

11,714 COMPOUND SEMICONDUCTOR DEVICES by H.C. Gorton, W.L. Mefferd, and R.K. Willardson (Battelle); U.S. Pat. 3,013,193, Issued Dec. 12, 1961

The use of aluminum tantalide, Al_3Ta, in semiconductor devices is discussed. The material exhibits a resistivity, 1 - 10 ohm-cm, which is suitable for semiconductor device applications. Single crystal whiskers of Al_3Ta are transparent, a characteristic of high band gap material. Al_3Ta melts at about 1700°C. The compound is prepared by dissolving up to 25 atomic per cent tantalum in aluminum at temperatures up to 1700°C and slowly cooling the melt. It can also be prepared by the direct reaction of the components at the melting point of the compound. Al_3Ta can be separated from aluminum by dissolving the aluminum in hydrochloric acid.

11,715 CRYSTAL GROWTH OF ZINC-OXIDE BY CHEMICAL REACTION OF ZINC-FLUORIDE WITH AIR by I. Kubo (Nagasaki U.); J. Phys. Soc. Japan, Vol. 16, pp. 2358-2359(L), Nov. 1961

The growth of single crystals of zinc oxide is described. The bottom of a platinum crucible containing zinc fluoride powder is heated at 1050°C for several hours while the top of the crucible is air cooled. Hexagonal, yellowish, transparent needlelike crystals are observed on the inside wall of the crucible where the temperature is about 950°C. The crystals are, typically, 15mm in length and 1 mm in cross section. Large crystals could be obtained by longer heating. Crystal perfection is improved by the presence of a steeper temperature gradient at the crucible wall. Steplike figures were observed on the surface of crystals grown by this technique.

11,716 THE GROWTH OF ELECTROLUMINESCENT AND PHOTOCONDUCTIVE SINGLE CRYSTALS OF ZINC SULFIDE [in Czech] by F. Karel (Czech. Akad. Nauk); Czech. J. Phys., Vol. 11B, p. 292(L), 1961

The preparation of ZnS single crystals for physical research is described. The conditions for the preparation of luminescent and pure single crystals and the method of activation with copper and manganese are given.

11,717 ZnS:Cu,Si PHOSPHORS by A. Wachtel (Westinghouse), J. Electrochem. Soc., Vol. 108, pp. 534-540, June 1961

The preparation of ZnS phosphors which exhibit orange fluorescence is described. The phosphors are prepared by firing ZnS, $(CH_3COO)_2Cu$, and SiS_2 under firing conditions which usually do not result in orange-emitting phosphors. The emission is produced by the simultaneous incorporation of Si which replaces vacancies or interstitial Zn atoms in proposed models for the orange-emitting copper center. With high concentrations of Cu and Si, a ternary (Zn, Cu, Si) S which may show a deep-red fluorescence peaked at 840 mμ is formed.

Preparation of:
Hybrid Garnets - See 11,861
Ferrimagnetic Garnets - See 11,862
Mn-Sn Ferromagnetic Systems - See 11,860

11,718 THE INFLUENCE OF HIGH PRESSURES AND HIGH TEMPERATURES ON TRANSFORMATIONS AND COORDINATION IN CRYSTALLINE AND VITREOUS CERAMIC MATERIALS by W.F. Claussen, R.C. Devries, and J.D. MacKenzie (GE Res. Labs.); U.S. Gov. Res. Rep., Vol. 35, p. 754(A), June 16, 1961 PB 171 595

An investigation of the effect of high pressures and temperatures on densification of vitreous silica and germania and on the polymorphism of crystalline Al_2SiO_5 using the high-pressure techniques developed for diamond synthesis is reported. Germania glass of a density approximately equivalent to that of the quartz-form germania was made by this technique. A shift of infrared reflection bands at 1110 cm^{-1} for SiO_2 and 895 cm^{-1} for GeO_2 suggested that the densification of the glasses is a result of the decrease of the M-O-M angle, but the over-all spectra for both compressed vitreous SiO_2 and GeO_2 are unchanged from the correspondingly less dense glasses. High temperature and pressure studies of the system Al_2SiO_5 established that high-pressure form kyanite melts to α-Al_2O_3 plus liquid. When kyanite is hot-pressed in its stability region, the grains show complex slip and kink patterns; but kyanite found under the same conditions from andalusite or sillimanite have simple grains possibly due to twinning. No region of liquid immiscibility was found in this system as might be expected.

CRYSTAL SURFACES

11,719 ANODIC OXIDATION OF GERMANIUM by T. Gabor (Westinghouse Res. Labs.); J. Appl. Phys., Vol. 32, pp. 1361-1363, July 1961

The formation of striations on etched samples of n-type or near-intrinsic p-type germanium upon anodic polarization is discussed. The periodic depletion of holes is advanced as a tentative explanation of the phenomenon.

11,720 SURFACE H_2O RETENTION OF P-TYPE GERMANIUM by S.S. Barid and C. Dennis (Texas Instr.); J. Electrochem. Soc., Vol. 108, p. 261C(A), Dec. 1961

The surface water stoichiometry of crushed Ge treated with acid, base, oxidizing, and water reagents was discussed. Except for hot HNO_3 treatment, negligible changes in water retained by the surface particles were observed. Similarly treated Si and Ge surfaces were compared. The Ge surfaces were more hydrophobic than Si surfaces with the exception of water-treated surfaces.

11,721 GENERAL THEORY OF MONOLAYER PHYSICAL ADSORPTION ON SOLIDS by W.A. Steele and M. Ross (Penn. State U.); J. Chem. Phys., Vol. 35, pp. 850-862, Sept. 1961

A theoretical monolayer adsorption isotherm which is written as a power series is presented. The terms involve integrals over the interaction energies of the adsorbed atoms with each other and with the solid. The treatment is based on a virial expansion of the density of the film in powers of the activity of the film, but excludes the effect of periodic variation of the solid-gas atom potential energy as the atom moves over the surface of the solid. The general equation reduces to the sitewise model for large parallel variations in the solid-gas atom energy, and to a perfectly mobile film for small variations. Some possible methods of dealing with adsorption systems which are neither completely localized nor completely mobile are outlined. Information about the nature of the solid-gas atom potential function may be obtained from an analysis of the experimental data for suitable systems.

Etch Pits on Vapor Phase Grown GaAs Crystals - See 11,712

11,722 ELECTROLYTIC ETCHING OF GERMANIUM AND OTHER SEMICONDUCTORS IN WATER by W. Rindner and R. Ellis, Jr. (Raytheon); J. Electrochem. Soc., Vol. 108, p. 261C(A), Dec. 1961

A method of electrolytically etching Ge, GaAs and GaP in water was discussed. The properties and mechanism of this new etching method have been studied with particular reference to Ge. It has been found that electrolytic etching with water provides good resolution where localized etching is desired. The etching rate is considerably higher than that reported for Ge using water as a chemical etchant.

11,723 ETCHING EXPERIMENTS IN SYNTHETIC QUARTZ [in German] by G. Gulzow-Qual (Opt. Werke, Jena); Phys. Status Solidi, Vol. 1, pp. 62-67, 1961

Etching experiments conducted on synthetic quartz in order to investigate the relation between etching cavities and certain growth-conditioned irregularities of the crystal are discussed. By a prolonged etching process, hollow channels are produced at many etching cavities and lead to inclusions and hollow spaces. These so-called etching channels are likely to develop at dislocations; they may originate from inclusions and cavities.

11,724 A MACHINE FOR CLEANING SEMICONDUCTOR SLICES by F.L. Gittler (Bell Labs.); J. Electrochem. Soc., Vol. 108, p. 261C(A), Dec. 1961

A machine for chemical cleaning of semiconductor slices was described. The materials of construction, method of slice transport, and handling of cleaning materials are such that highly corrosive agents can be used to accomplish the cleaning. Provision is made to clean at elevated temperatures. At present, 30 slices per hour are being produced.

ENVIRONMENTAL EFFECTS

Effects of Annealing upon Recombination in Si - See 11,763

Effect of Radiation Induced Defects upon Carrier Lifetimes in InSb - See 11,761

11,725 THE PENETRATION OF ELECTRONS INTO SOLIDS. Part I. THE INTENSITY OF AN ELECTRON BEAM, TRANSVERSE PATHS OF ELECTRONS by A.F. Makhov (Leningrad Inst.); Soviet Phys.-Solid State, Vol. 2, pp. 1934-1941, Mar. 1961

A number of experiments on the passage of electrons through thin films of Al, Si, Cu, Ge, Bi, and Al_2O_3 are discussed. A method is described which can give curves determining the intensity of the electron beam in thick specimens of a solid in a form which is universal either with respect to the initial energy of the electron (if the intensity is considered as a function of the depth) or with respect to the depth (if the intensity is considered as a function of the initial energy of the electron). Experimental formulas which describe the intensity of the electron beam are obtained. It is shown that the transverse paths of the electrons, forming the path spectrum, are connected with the initial energy by a functional dependence of the same type. The ratio of any of the paths to the mean square or the mean to the paths, i.e., their relative value, is independent of the initial energy of the electrons.

11,726 THE PENETRATION OF ELECTRONS INTO SOLIDS. Part II. THE DISTRIBUTION OF ELECTRONS IN DEPTH by A. F. Makhov (Leningrad Inst.); Soviet Phys.-Solid State, Vol. 2, pp. 1942-1944, Mar. 1961

The distribution of electrons in depth is considered for six substances: Al, Si, Cu, Ge, Bi, and Al_2O_3. The possibility of representing the distribution in a form which is universal with respect to the initial energy of the electrons is shown. From the form of the distribution it is concluded that, within the limits of the depths of distribution, it is not possible to pick out any narrow layer for which it would be possible to assume localized absorption of the electrons of the beam.

11,727 THE PENETRATION OF ELECTRONS INTO SOLIDS. Part III. THE ABSORPTION OF THE ENERGY OF AN ELECTRON BEAM by A.F. Makhov (Leningrad Inst.); Soviet Phys.-Solid State, Vol. 2, pp. 1945-1951, Mar. 1961

A method for calculating the characteristics determining the absorption of electron energy by solids is described. The method was developed from experimental regularities described in the first part of the work, and relating to the transverse paths of electrons and the intensity of an electron beam. For six substances — Al, Si, Cu, Ge, Bi, and Al_2O_3 — a calculation is carried out for the distribution of electrons with regard to energies and mean energy of the electrons at an arbitrary depth

within a solid, and also the dependence of the energy absorbed by the indicated solids on the depth.

Radiation Induced Effects in Solids - See 11,911

SOLID STATE PHYSICS

GENERAL

11,728 ELECTROMAGNETIC PROPERTIES OF INSULATORS FROM A MANY-PARTICLE POINT OF VIEW by V. Ambegaokar (Carnegie Inst. Tech.); U.S. Gov. Res. Rep., Vol. 35, p. 568(A), May 16, 1961 PB 153 776

The response of insulators to weak long-wavelength electromagnetic fields is discussed from a many-particle point of view. The model consists of a lattice of nuclei (supposed rigid and of cubic symmetry) and electrons which interact with these nuclei as well as with each other. The Coulomb interactions between the electrons are allowed for to all orders of perturbation theory, and Feynman graphs are introduced to describe the terms of the perturbation series. The perfect insulator is treated and results show that the response of this many-particle system to long wavelength electric fields of arbitrary polarization is exactly contained in a single frequency-dependent dielectric constant. In the limit of long wavelengths and low frequencies, the effects of an external magnetic field in the system are included. The system of insulator plus one electron is treated using methods similar to those applied to the perfect insulator.

11,729 EXCHANGE INTERACTION BETWEEN CONDUCTION ELECTRONS AND MAGNETIC SHELL ELECTRONS IN RARE-EARTH METALS by S.H. Liu (Iowa State U.); Phys. Rev., Vol. 121, pp. 451-455, Jan. 15, 1961

The interaction Hamiltonian for the Coulomb exchange effect between conduction electrons and magnetic shell electrons in rare-earth metals is derived from first principles. The approximations under which the interaction can be represented by the product of electron and ion spin vectors are exhibited.

11,730 STUDIES, RESEARCH, AND INVESTIGATIONS ON COMPOUNDS FORMED FROM ELEMENTS OF GROUPS II AND VI OF THE PERIODIC TABLE by C.M. Chapman, B. Paris et al. (Battelle); U.S. Gov. Res. Rep., Vol. 35, p. 793(A), June 16, 1961 PB 153 923

Studies of the properties of HgSe prepared by the Bridgman method are reported. The best crystals have carrier densities at room temperature on the order of 10^{17} cm^{-3}; annealing and doping with copper have not reduced carrier density significantly. A sound ingot produced from vapor deposition of HgSe is comparable in quality to ingots prepared by the Bridgman method. Optical transmission measurements on HgSe reveal a dependence of transmission edge on carrier density. As the carrier density is reduced, the transmission edge moves to longer wavelengths. An edge at $\sim 12\mu$ at room temperature was observed in a sample of 3.5×10^{17} cm^{-3} carrier density. Reflectivity and transmission data have permitted a rough calculation of the effective mass of carriers in HgSe. The ratio of effective mass to free-electron mass was computed to be in the neighborhood of 0.05. Studies on the HgTe-CdTe alloy system reveal that a material of nominal composition 90HgTe-10CdTe has a transmission edge within the 8 to 14 μ wavelength region. The position of the edge moves to longer wavelengths with decreasing cadmium content. The shift of transmission edge with temperature is on the order of 1×10^{-4} ev/°C. Hall measurements at low temperature show that the low-cadmium-content alloys made thus far are p-type, having a hole-to-electron mobility ratio from 0.035 to 0.01.

CRYSTAL PHYSICS

ENERGY BAND STRUCTURE

11,731 ONE-ELECTRON ENERGY BAND METHOD by L.J. Eyges (Lincoln Lab.); Bull. Am. Phys. Soc., Ser. II, Vol. 6, p. 108(A), Mar. 20, 1961

A new method for the one-electron energy band problem (i.e., for an electron bound to a periodic lattice) was presented. Starting from the well-know equation for $C(K_i)$, the Fourier coefficients of the wave function

$$C(K_i) = -\Omega_b \left[\frac{\Sigma\, C(K_j)\, w\,(K_i - K_j)}{\{(K_i + k)^2 + \beta^2\}}\right],$$

$C(K_i)$ is expanded in spherical (or Kubic) harmonics and the given equation is reduced to a set of coupled equations for the radial parts of the $C(K_i)$ in reciprocal lattice space. This set of equations can be truncated to a good approximation, yielding a set of homogeneous equations relating the amplitudes $C(K_i)$ evaluated at different absolute magnitudes of the reciprocal lattice points. For $k = 0$, the energies and wave functions of low excited states can be found to very high accuracy by use of computer techniques.

11,732 TRANSMISSION LINE FORMULATION FOR SEMICONDUCTORS by P. Parzen (Polytech. Inst. Brooklyn); U.S. Gov. Res. Rep., Vol. 35, p. 629(A), May 16, 1961 PB 153 932

A transmission line method of treating band structure, wherein the crystal is divided into periodically displaced regions bounded by crystal planes passing through atomic sites which contain subregions with almost constant potential, is discussed. The Schroedinger equation is solved in the subregions in terms of incident and scattered plane waves satisfying proper Bloch conditions in directions parallel to the crystal planes. The incident and scattered waves are related via the scattering of an electron wave by the 2-dimensional lattice of a crystal plane. The plane wave amplitudes are constrained to satisfy the Bloch condition along a lattice direction not parallel to the crystal places, thereby determining energy as a function of wave number. Different atoms per unit cell require the solution of appropriate scattering problems which may be tabulated and used to compute the band structure of solids built up of arbitrary crystal planes. The symmetry properties induced by the symmetry operations of the two-dimensional lattices in the crystal plane are determined. Detailed computations for Li are given.

11,733 ENERGY-BAND STRUCTURE OF SOLIDS FROM A PERTURBATION ON THE "EMPTY LATTICE" by F. Bassani (Argonne Natl. Labs.) and V. Celli (U. Illinois); J. Phys. Chem. Solids, Vol. 20, pp. 64-75, June 1961

A simple perturbation method for obtaining the energy-band

structure of solids is described. The unperturbed Hamiltonian consists of the kinetic part of a uniform potential; the perturbing operator is the crystal potential plus a term which originates from the requirement that valence and conduction states be orthogonal to the inner states. This amounts to an approximation to the O.P.W. method. Reasons are given for the validity of such a simple scheme and applications are made to the case of the diamond lattice and of the zincblende lattice. It is shown how features of the energy-band structure depend on the symmetry of the lattice, on the lattice parameter and on the "core states" of the atomic components. Numerical results obtained for diamond, silicon and boron nitride are in fair agreement with recent calculations. An energy-band structure consistent with experimental information is obtained for Ge and GaAs by fixing the values of a few parameters.

Thermomagnetoelectric Determination of Energy Band Structure - See 11,933

Energy Band Structure of:
Ge - See 11,807
PbTe - See 11,887
Mg-Cd - See 11,930
Gray Tin - See 11,807

11,734 THE IONIZATION BEHAVIOR OF DONORS FORMED FROM OXYGEN IN GERMANIUM by C.S. Fuller and F.H. Doleiden (Bell Labs.); J. Phys. Chem. Solids, Vol. 19, pp. 251-260, May 1961

Hall and conductivity measurements on a series of oxygen-doped Ge crystals in which donors were formed by oxygen aggregation are discussed. Three donor energy levels (~0.2, 0.04, and 0.017 ev) are found in partially reacted crystals. The shallowest level (0.017 ev) alone appears to be left on complete reaction and is therefore attributed to the donor containing four oxygen atoms. The other two levels are attributed to donors containing fewer oxygen atoms. In particular, there is substantial evidence favoring the assignment of the 0.2 ev level to the donor containing two oxygen atoms. The concentration of the 0.04 ev donor level is found to depend on temperature and time in a manner which suggests an internal rearrangement of the oxygen atoms. The energetics of this process have been studied and an attempt has been made to account for the results on the basis of an equilibrium between two forms of the donor. The bearing of the results on reaction kinetics is discussed.

11,735 CANCELLATION OF KINETIC AND POTENTIAL ENERGY IN ATOMS, MOLECULES, AND SOLIDS by M.H. Cohen (U. Chicago and Hughes Res. Labs.) and V. Heine (Cavendish Lab.); Phys. Rev., Vol. 122, pp. 1821-1826, June 15, 1961

In the energy levels of valence electrons in atoms, molecules, solids, and liquids, there is a contribution from the large negative potential energy inside the core of the atom and the large positive kinetic energy which the electron has there. Phillips and Kleinman have shown how the kinetic energy can by represented by a repulsive pseudopotential which cancels most of the potential energy inside the core. The explicit representation of the pseudopotential is developed further to demonstrate more clearly the extent of the cancellation. The formalism justifies the simple models which are in common use for treating valence electrons. It is also used to relate similar atoms from different rows of periodic table, and in particular to discuss the systematic trends in the energy levels of the alkali and noble metal atoms.

11,736 VALENCE SPIN-ORBIT SPLITTING AND CONDUCTION g TENSOR IN Si by L. Liu (U. Chicago); Phys. Rev. Lett., Vol. 6, pp. 683-688(L), June 15, 1961

Calculations showing that the valence spin-orbit splitting at Δ is too small by a factor of 3 to explain the experimental g shift are presented. The spin-orbit splitting of the valence band is derived by crystal wave functions of the orthogonal plane wave method which are divided into a smooth plane wave part and a core part. In computing

$$\langle \Psi_k^{\vec{\alpha}} | H_{S.O.} | \Psi_k^{\vec{\beta}} \rangle,$$

where $H_{S.O.}$ is the spin-orbit operator, 96 per cent of the matrix element is found to come from core-core terms. The spin-orbit splitting of the p valence bands along $\vec{k} = (\Delta 00)$ is therefore conveniently expressed in terms of the 2p core orbitals. Sketches of the spin-orbit splitting of the Δ_5 valence band and of the energy bands along the [100] axis of the Brillouin zone are provided. Tables of spin-orbit splitting of the 2p core state and of the relative magnitude of contributions to the g tensor are also included.

11,737 EFFECT OF INTERACTIONS ON DETERMINATION OF FERMI SURFACES by E.A. Stern (U. Maryland); Phys. Rev., Vol. 122, pp. 1773-1780, June 15, 1961

The effect of both electron-electron and electron-phonon interactions on a degenerate electron gas in a uniform positive background is discussed. It is shown that when electron-electron interactions alone are considered the free-electron mass is still measured by cyclotron resonance, the Faraday effect, and optical constants. However, the period of the de Haas-van Alphen oscillations is changed from what one calculates neglecting interactions and is changed in the same way that the specific heat is. When electron-phonon interactions are added, everything changes. In particular, it is shown that the cyclotron mass is no longer the free value, and the de Haas-van Alphen period and the specific heat are changed in different ways. Comparison with measurements on aluminum which approximates the model used shows that both electron-phonon and electron-electron effects are important and of the same magnitude.

11,738 ON THE FERMI SURFACE SHAPES OF THE NOBLE METALS BY ULTRASONICS by R.W. Morse, A. Myers, and C.T. Walker (Brown U.); J. Acoust. Soc. Am., Vol. 33, pp. 699-700(L), May 1961

Some revised conclusions concerning the Fermi surface shapes of the noble metals, determined by ultrasonic means, are discussed. The main new conclusions are: (1) The relative amount of zone boundary touching in copper and gold is nearly the same. (2) There is evidence that the main bodies of the surfaces are considerably more distorted than previously believed, being bulged outward along the [100] axis and possibly being concave in the [110] direction.

Fermi Surface of Ga - See 11,813

LATTICE VIBRATIONS AND ELECTRONIC STRUCTURE

11,739 LATTICE VIBRATIONS OF ZINCBLENDE STRUCTURE CRYSTALS by H. Kaplan and J.J. Sullivan (Syracuse U.);

Bull. Am. Phys. Soc., Ser. II, Vol. 6, pp. 279-280(A), Apr. 24, 1961

The lattice vibration spectrum of zincblende structure crystals in symmetry directions in the Brillouin zone was calculated using the shell model previously used by Cochran et al. to study germanium and alkali halide crystals. The parameters of the model (shell and core charges, shell springs and short range force constants) were adjusted to fit the elastic, piezoelectric and high and low frequency dielectric constants. Care was taken to ensure that the model corresponded to zero pressure in equilibrium. The zincblende structure differs from the alkali halides in that the polarizabilities affect the elastic constant C_{44}. A comparison calculation using the Born and Huang model, which includes long-range but not short-range polarization effects, reveals the same instability for short wave lengths in the <100> directions as was found earlier for the alkali halides. The work was compared to a calculation of Merten which used a rigid ion model.

11,740 APPLICATION OF GROUP-THEORY METHODS TO STUDY THE LATTICE OSCILLATIONS OF TELLURIUM by Yu. L. Rabotnikov (Acad. Sci. USSR); Soviet Phys.-Solid State, Vol. 2, pp. 1879-1890, Mar. 1961

Relations between the frequencies and interatomic force constants are derived. The secular equation for oscillations of the Te (or Se) lattice is greatly simplified for a series of lines in the Brillouin zone. The presence of degeneracies due to lattice symmetry is demonstrated.

11,741 ON THE ELECTRONIC STRUCTURE OF METALLIC IMPURITIES IN THE TIGHT BINDING APPROXIMATION [in French] by G. Leman (Faculté Sci., Orsay); J. Phys. Chem. Solids, Vol. 20, pp. 50-63, June 1961

The electronic structure of metallic impurities is studied in the tight binding approximation. It is shown, on the simple example of a linear chain, that only some stationary wave functions (in this case, the symmetric ones) are appreciably perturbed. Various general results concerning the density of charge displaced by an impurity atom and its relations to the phase shift of the wave functions at the Fermi level are obtained directly. The possible extension to three dimensions of these results is discussed qualitatively.

11,742 RELATIONSHIPS BETWEEN ELECTRONIC STRUCTURE AND PHYSICAL PROPERTIES IN TRANSITION METALS [in Italian] by G. Airoldi (CISE Lab., Segrate) and M. Asdente (Politecnico, Milano); Energia Nucleare, Vol. 8, pp. 342-360, Mar. 1961

Some physical properties of the transition metals are considered and the main similarities among the three series are outlined. Theoretical pictures which have been put forward concerning the electronic states and wavefunctions of transition metals are described (in particular the independent electron models). The results of theoretical calculations carried out with different approximations are given.

ELECTRICAL PROPERTIES

DIELECTRIC PROPERTIES

11,743 MEASUREMENT OF SMALL DIELECTRIC LOSSES IN MATERIAL WITH A LARGE DIELECTRIC CONSTANT AT MICROWAVE FREQUENCIES by R.O. Bell and G. Rupprecht (Raytheon); IRE Trans., Vol. MTT-9, pp. 239-242, May 1961

A method for measuring dielectric losses at microwave frequencies in materials with a large dielectric constant is described. By observing a dielectric resonance in a sufficiently large sample, the loss tangent of the material can be obtained. Results on $SrTiO_3$ single crystals at 20 kMc are presented.

11,744 HIGH-DIELECTRIC-CONSTANT MATERIALS AS CAPACITOR DIELECTRICS. A STUDY IN DIELECTRIC SPECTROSCOPY by A. von Hippel and W.B. Westphal (MIT); U.S. Gov. Res. Rep., Vol. 35, p. 572(A), May 16, 1961 PB 152 128

The electrical properties of materials of normal dielectric constant (Al_2O_3 and $MgTiO_3$) are compared with those of high dielectric constant (TiO_2, $CaTiO_3$, $SrTiO_3$, $[Ba_{0.65}Sr_{0.35}]$ TiO_3 and $BaTiO_3$. Single crystals and ceramics have been investigated from dc to the microwave range as a function of time, temperature, field strength, and prehistory. Three types of relaxation spectra have been identified; one is caused by dipolar groups in unequal double wells, and the other 2 are caused by charge carriers stopped in the volume of the material or in front of the electrodes, respectively. O-H groups in rutile, identified by IR absorption, appear to cause a dipolar spectrum by thermal excitation leading to H-bond formation. The nonlinear response characteristics of $BaTiO_3$ and $(Ba_{0.65}Sr_{0.35})$ TiO_3 in the ferro- and paraelectric range and the onset of ferroelectricity for $SrTiO_3$ at liquid-He temperature have been measured. Some dc breakdown data for ceramics, and impulse and dc strength measurements on rutile single crystals parallel and perpendicular to the axis are given.

11,745 DIELECTRIC PROPERTIES OF SnO_2 by L.V. Deshpande and V.G. Bhide (Inst. Sci., Bombay); Nuovo Cim., Vol. 19, pp. 816-817(L), Feb. 16, 1961

The dielectric properties of SnO_2 are discussed. SnO_2 exhibits an astonishingly high value of dielectric constant (of the order of 10^5). Unlike other oxidic semiconductors such as Ni-Zn ferrites etc., the dielectric constant of SnO_2 is not so markedly dependent on the applied frequency in the audio frequency range. The dielectric constant of SnO_2 increases with the applied voltage and attains a maximum value at a certain temperature, T_c, which fluctuates within a small range from sample to sample and with the biasing field. A dielectric hysteresis loop has been observed which shows the existence of spontaneous polarization, a characteristic of every ferroelectric substance.

Dielectric Constant of Ge - See 11,773

11,746 VARIATION OF PERMITTIVITY WITH ELECTRIC FIELD IN PEROVSKITE-LIKE FERROELECTRICS by H. Diamond (U. Michigan); J. Appl. Phys., Vol. 32, pp. 909-915, May 1961

A model for the case of polycrystalline ferroelectrics in which each crystallite is presumed to behave according to a free-energy function of the type formulated for $BaTiO_3$ by A.F. Devonshire [Advances in Phys., Vol. 3, p. 85 (1954)] is discussed. The Curie temperatures for the individual grains are taken in a Gaussian distribution about some chosen temperature. The permittivity is obtained by averaging with this distribution over all of the crystallites. In accordance with the free-energy function, it is assumed that the electric field induces a ferroelectric axis in those crystallites of the distribution which are not ferroelectric at a given temperature. On the basis of experimental evidence, 90° reorientation of domains in the ferroelectric

part of the distribution is presumed to be negligible for semi-static and dynamic fields. Despite the seemingly severe restriction imposed by the latter assumption, a large field sensitivity is predicted. Agreement between the theory and experimental data is excellent for both parallel and transverse fields. It is concluded that the variation of incremental permittivity is associated with an induced ferroelectric state rather than being directly a property of domain processes, and that a large variation with field must necessarily be accompanied by strong thermal sensitivity.

11,747 INVESTIGATION OF THE MICROWAVE PROPERTIES OF FERROELECTRICS by G. Rupprecht, B.D. Silverman, and R.J. Bell (Raytheon); U.S. Gov. Res. Rep., Vol. 35, p. 797(A), June 16, 1961 PB 154 077

Measurements of the complex dielectric constants of single crystal strontium titanate and polycrystalline barium-strontium-titanate over a temperature range extending from 90° to 230°K and a frequency range from 2.30 to 6.50 kMc are reported. The real part of the dielectric constant consists of a large field-independent contribution which obeys a Curie-Weiss law over the entire range of measurement plus a smaller anisotropic field-dependent contribution. The results are shown to be in qualitative agreement with the theory of ferroelectricity in perovskite structures as proposed by Slater. The observed loss tangent consists of a contribution which is quadratic in an applied biasing field plus a smaller field-independent contribution. The field-independent loss tangent goes through a minimum at about 170°K with a much steeper rise on the low temperature side of the minimum than on the high temperature side. A theory for the temperature dependence of the field-independent loss tangent is proposed which agrees with the data within experimental accuracy. The theory also predicts a contribution to the loss tangent which is proportional to an applied biasing field; however, the rapid decrease with increasing temperature is not understood.

11,748 SOME REMARKS ON PHASE TRANSITIONS OF THE SECOND KIND AND THE MICROSCOPIC THEORY OF FERROELECTRIC MATERIALS by V.L. Ginzburg (Levedev Phys. Inst.); Soviet Phys.-Solid State, Vol. 2, pp. 1824-1834, Mar. 1961

An explanation of the special features of various transitions of the second kind (in superconductors, liquid helium, ferromagnetic materials, ferroelectric materials, and so on) using the different values of the ratio of the volume and correlation energies is discussed. The microscopic theory of ferroelectric materials is discussed in terms of a comparison of an anharmonic-oscillator model with a general model of the vibrating crystal lattice. The behavior of the frequency of the optical vibrations near the transitions point is elucidated.

11,749 MODELS FOR SWITCHING IN FERROELECTRICS by D.J. White (U.S. Naval Ord. Lab.); J. Appl. Phys., Vol. 32, p. 1169(L), June 1961

Criteria for the validation of three switching models applicable to ferroelectrics are discussed. Starting from an expression for the polarization as a function of time, according to the particular model being considered, a set of mutually exclusive inequalities is derived. Thus any experimentally obtained switching transient quickly rules out the applicability of two of the models.

11,750 INTERDOMAIN SYMMETRY IN THE REVERSIBLE PHASE TRANSFORMATION OF POTASSIUM CYANIDE by A. Cimino (Centro Nazionale Ricerche, Rome) and G.S. Parry (Imperial College, London); Nuovo Cim., Vol. 19, pp. 971-980, Mar. 1961

The orientation of domains in transformed single crystals of KCN is considered in detail by means of stereographic projections is discussed. The elements of point group symmetry of the high temperature phase divide on transformation into the intradomain symmetry elements that are preserved in the new crystal structure and the interdomain symmetry elements that relate individual domains possessing this new structure. A method of deriving the number of independent domain orientations is given in terms of these concepts and is applied to the alternative transformation schemes of KCN. Consideration is also given to the physical aspects of domain coexistence in KCN. The lattice changes which take place on transformation are considerable and it is shown that although invariant lattice planes common to two domain orientations do exist in some cases, such a continuous transformation mechanism cannot account for all the domain orientations observed experimentally. An earlier conclusion that discontinuous processes must also occur is confirmed.

11,751 AGING OF FERROELECTRICS. Part I. SYMMETRY OF THE LOW TEMPERATURE PHASE OF BARIUM TITANATE. Part II. by E. Sawagushi and M. Charters (Rutgers State U., New Brunswick); U.S. Gov. Res. Rep., Vol. 35, p. 795(A), June 16, 1961 PB 150 915

The mechanism of aging in solid solution types of ferroelectrics is discussed. A theory previously developed, which attributes the aging to the growth and stabilization of a polar anisotropy, has been substantiated for the case where the polar anisotropy is due to composition differences within the ceramic solid solution, $Pb_xCa_{1-x}TiO_3$. Dielectric data, X-ray analysis, and double hysteresis loop observations were the principal methods used. Barium titanate must derive its polar anisotropy from a different mechanism. The present studies show that the surface of $BaTiO_3$ ceramics has a preferred domain orientation, which is quite stable. This is probably a major factor for the growth and stabilization of a polar anisotropy. A third mechanism is suggested by the growth of a polar anisotropy caused by gamma of neutron irradiation. The domain patterns and optical properties were examined using thin (111) plates in order to find the crystal symmetry of $BaTiO_3$ below -80°C. Four kinds of optically uniaxial domains were differentiated. The crystal symmetry proved to be rhombohedral.

11,752 FERROELECTRICITY IN (K, NH_4), (K,Rb) AND (K, Tl) FERROCYANIDE MIXED CRYSTALS by S. Waku, K. Masuno, and T. Tanaka (Nippon Tel. and Tel.); J. Phys. Soc. Japan, Vol. 16, pp. 1158-1161, June 1961

Ferroelectric properties of potassium ferrocyanide which contains other monovalent positive ions (NH_4, Rb, and Tl) are discussed. An increase in the amount of these substituents causes a shift in the peak of the dielectric constant vs temperature curve towards the low temperature side. Substituted compounds containing a relatively small amount of these substituents show ferroelectric behavior similar to that of potassium ferrocyanide trihydrate.

11,753 MEASUREMENTS OF PIEZORESISTIVITY IN Bi_2Te_3 by T.J. Diesel and L.E. Hollander, Jr. (Lockheed); Bull. Am. Phys. Soc., Ser. II, Vol. 6, p. 312(A), Apr. 24, 1961

Measurements of the piezoresistive effect in single crystals of p-type Bi_2Te_3 which were cleaved from an ingot along the (0001) cleavage plane were reported. The room temperature value of the longitudinal piezoresistive coefficient π_L, measured along this cleavage plane, was found to be $+87 \times 10^{-12}$ cm^2/d, and its temperature dependence was determined from -40° to +60°C. The hydrostatic coefficient π_H is about -40×10^{-12} cm^2/d, indicating a negative transverse coefficient which was qualitatively observed. Measurement of the Hall coefficient gave a carrier concentration of 5×10^{19} carriers/cm^3, with a resistivity of 10^{-3} ohm-cm. The piezoresistive coefficients were measured by compressing a specimen longitudinally to a stress of about 3×10^7 d/cm^2 and hydrostatically to 4×10^8 d/cm^2. Because of the high acceptor concentrations in the samples studied, the many-valley energy surface theory is no longer valid, and the observed piezoresistive effect can be attributed to scattering.

11,754 SOME PECULIARITIES OF THE PIEZOELECTRIC EFFECT IN BARIUM TITANATE by E.A. Shamro (V.G. Belinskii Nikolaev State Pedag. Inst.); Soviet Phys.-Solid State, Vol. 2, pp. 1871-1873, Mar. 1961

Measurements of the remanent piezoelectric effect in polarized polycrystalline barium titanate specimens under static conditions by the method of hot polarization are reported. The advantages of this method in comparison with room-temperature polarization are demonstrated. The existence of a number of qualitatively different components of the piezoelectric modulus has been established. These components differ in regard to the temperature behavior of the piezoelectric modulus and in the location of its temperature maximum.

11,755 TRANSMISSION-TYPE PIEZOELECTRICITY DETECTOR by R.J. Blume (IBM); Rev. Sci. Instr., Vol. 32, p. 598(L), May 1961

A differential transmission circuit used to detect piezoelectric crystals is described. The circuit is designed on the assumption that the crystal and its holder are fairly well approximated (except at resonance) by a capacitance which can be the entire transmission element. The device has been used at room temperature and has furnished a correct indication in all tests concerning properties of known substances. The circuit subtracts most of the noise originating in the RF source. Though a spurious indication of instrumental origin is always observed over the range 40 - 50 Mc, it has been ignored since the range is well above the one at which true resonance occurs.

Piezoresistivity of SiC - See 11,786

11,756 SOME INQUIRY INTO THE POLARIZATION PHENOMENON AND THE ELECTRO-STRICTION EQUATION OF BARIUM TITANATE CERAMIC [in Japanese] by Y. Tomita and T. Yamaguchi (Elect. Commun. Lab., Tokyo); Abstracts of J. Inst. Elect. Commun. Engrs. Japan, Vol. 44, p. 4(A), Mar. 1961

Parameters relating to the two polarization directions of $BaTiO_3$ were discussed. The effect of each polarization in the electrostriction equation, which describes the electric bias field dependence of the dielectric constant and the elastic compliance of $BaTiO_3$, was cited.

11,757 BEHAVIOR OF HOT ELECTRONS IN MICROWAVE FIELDS by B.V. Paranjape (Louisiana State U.); Phys. Rev., Vol. 122, pp. 1372-1375, June 1, 1961

The currents produced by electrons in a microwave field are investigated theoretically. Two special cases are treated: Case (A) deals with a strong steady electric field on which a weak microwave field of frequency ω is superimposed. In addition to a steady current, an alternating current of frequency ω is found which leads the microwave field. The phase difference is negligible at low frequency, but becomes appreciable at frequencies $\omega \approx (1/\tau_0)(1/100)$, at liquid-nitrogen temperature. Here τ_0 is the electron-phonon relaxation time of thermal electrons. Only interaction with acoustic modes is considered. In Case (B), the effect of a strong microwave field by itself is considered. Here the current has a strong component of frequency ω and a weaker component of frequency 3ω. Phases similar to those in Case (A) are found. Results for Case (B) are valid if $1/\tau_0 > \omega > (1/\tau_0)(1/100)$ at liquid-nitrogen temperature.

11,758 NEGATIVE RESISTANCE AND HOT ELECTRONS by I. Adawi (Battelle); J. Appl. Phys., Vol. 32, pp. 1101-1111, June 1961

Current-voltage characteristics of hot electrons are analyzed for negative resistance regions. Electrons in a homogeneous semiconductor are assumed to interact only with acoustical phonons and charged centers of heavy mass. These charged centers could be ionized impurities or heavy holes with a negligible contribution to the current. A distribution function which ignores electron-electron collision almost certainly does not lead to negative resistance. A postulated Maxwellian distribution may lead to a current discontinuity, but does not lead to a stable region of negative resistance, contrary to previous conclusions. For any physical distribution it is shown that the average electron energy increases monotonically with field strength. These results also apply to situations in gaseous discharge where hot electrons are scattered by neutral molecules and ions.

11,759 THE EXCITON EXAMINED FROM THE POINT OF VIEW OF INTERMEDIATE BINDING WITH DUE REGARD TO TRANSLATION by I.G. Zaslavskaya (Acad. Sci. Ukr SSR); Soviet Phys.-Solid State, Vol. 2, pp. 2002-2005, Mar. 1961

An investigation of the exciton ground state with due regard to translation, carried out by the intermediate-bond method of Buimistrov and Pekar, is discussed. The exciton ground-state energy reduction obtained derives from consideration of translational symmetry and also from the effective-mass value.

11,760 MEASUREMENT OF MINORITY CARRIER LIFETIMES IN SiC BY A NOVEL ELECTROLUMINESCENT METHOD by G.G. Harman and R.L. Raybold (Natl. Bu. Stand.); J. Appl. Phys., Vol. 32, p. 1168(L), June 1961

A method of measurement of the minority carrier lifetime of semiconductors with large energy gaps in which carriers are injected via a poor contact or rectifying junction until recombination produces a constant electroluminescent output is described. When the frequency approaches the carrier lifetime, the intensity decreases sharply. The method requires only simple equipment such as a variable frequency generator, an RF voltmeter, a photomultiplier, and a dc microammeter. No special size or crystal shape is required, subject to the limitation that the crystal should be longer than the minority carrier

diffusion length. Lifetimes less than 0.1 μsec are most easily measured by this means.

11,761 EXCESS CARRIER LIFETIME IN INDIUM ANTIMONIDE by R.A. Laff (Purdue U.); U.S. Gov. Res. Rep., Vol. 35, pp. 796-797(A), June 16, 1961 PB 148 016

Photoconductive and photoelectromagnetic measurements of the temperature dependence of lifetimes of excess majority and minority carriers in n- and p-type InSb samples of various carrier concentrations are reported. Analysis of the results leads to a model for the recombination consisting of a donor center having energy levels at 0.055 and 0.12 ev above the valence band. The recombination rates for electron and hole capture for both levels were obtained. Data on p-type samples in the majority carrier freezeout range indicates that excess holes may freeze out onto acceptor centers. Under steady state without optical excitation between valence band and acceptors, the holes on the acceptors must be in statistical equilibrium with the free holes. An increase in free hole concentration is accompanied by an increase of trapped holes in the acceptors. Additional centers of the same type present in as grown crystals were introduced into p-type material by bombardment with 4.5 Mev electrons. This result indicates that the centers originate from structural imperfections in the crystal lattice rather than from chemical impurities.

11,762 RECOMBINATION AT COPPER AND AT NICKEL CENTRES IN P-TYPE GERMANIUM by B.H. Schultz (Philips); Philips Res. Rep., Vol. 16, pp. 182-186, Apr. 1961

An observed difference in the temperature dependence of the recombination rates at copper centers for partly compensated and noncompensated crystals is attributed to the additional recombination at neutral copper atoms, assuming $\sigma_n \approx 10^{-16}$ cm^2. The contradiction in the existing literature discrepancies can be solved in this way. However, discrepancies for recombination at nickel centers have not been solved. Measurements in agreement with those of Wertheim are reported.

11,763 EFFECT OF THERMAL TREATMENT OF SILICON ON MINORITY-CARRIER LIFETIME by V.A. Atsarkin and E.Z. Mazel'; Soviet Phys.-Solid State, Vol. 2, pp. 1874-1878, Mar. 1961

An investigation of the effect of thermal treatment between 400° and 700°C on the minority-carrier lifetimes in n- and p-type Si grown from the melt by the Chochralski method is reported. The results of the quenching study agree with the similar studies by Bemski and Ross and Madigan. The effect on lifetime of the rate of cooling after high temperature treatment of the Si was also studied. An investigation of annealing of Si after quenching showed that the formation of recombination centers in Si is determined by the annealing process as well as by the exposure to the high temperature. A parallel study of etch pits on Si showed the relation between the density of etch pits and quenching and annealing phenomena.

11,764 RECOMBINATION CURRENT IN P-N JUNCTIONS AND DISTRIBUTIONS OF DEATHNIUM by W. Shockley and R. Henley (Shockley); Bull. Am. Phys. Soc., Ser. II, Vol. 6, p. 106(A), Mar. 20, 1961

Recombination current in Si p-n junctions and distributions of deathnium were discussed. In a forward biased p-n junction the current is carried by recombination through deathnium centers in the space charge layer and varies with voltage V as $\exp(qV/AkT)$, where A changes from 1 at low forward bias to 2 at high forward bias. When A is 2, the recombination occurs chiefly through centers in a layer approximately $2kT/qF = 10^{-6}$ cm wide, where F is the electric field. The location of this layer may shift with applied voltage. If the layer shifts to regions of lower deathnium density, the slope of log I vs V may become less than q/2kT corresponding to A values greater than 2. These effects are relevant to the problem of solar cell efficiency.

11,765 DETERMINATION OF ELECTRON TRAP DEPTH IN ZnS PHOSPHORS BY FLASH UNDER THE ACTION OF INFRARED LIGHT by L.A. Vinokurov and M.V. Fok (Acad. Sci. USSR); Optics and Spectrosc., Vol. 10, pp. 188-191, Mar. 1961

Determination of the depths of electron traps in the phosphors ZnS-Cu, Co (0.40 ev); ZnS-Cu, Ni (0.56 ev); ZnS-Cu (0.3 and 1.1 ev), and in the crystal ZnS-Cu (0.66 ev) from the temperature dependence of the intensity of the infrared induced flash in the late states of afterglow is reported.

11,766 EXPERIMENTAL STUDIES ON ELECTRONIC TRAPPING PROCESSES ASSOCIATED WITH DISLOCATION LINES IN ALKALI HALIDE CRYSTALS by H. Ohkura (Osaka U.); J. Phys. Soc. Japan, Vol. 16, pp. 881-895, May 1961

The trapping of conduction electrons by dislocation lines in alkali halide crystals is discussed. This phenomenon has been investigated by measuring the temperature dependence of photoconductance of deformed and undeformed crystals, and also by observing thermally stimulated currents. In both cases measurements of electric currents were carried out using ac in order to avoid undesirable effects due to space charge formation. Special care was exerted to obtain crystals having a high degree of purity. From the first experiment, the effective width of dislocation lines for electron trapping is estimated to be 9.3×10^{-8} cm using dislocation densities determined from NMR studies. The thermal depth of dislocation lines is estimated to be 0.21 ev for KBr and 0.24 ev for KCl crystals. A current glow peak, which presumably may correspond to trapping by jogs, has also been measured. The thermal depth of jogs is roughly estimated as 0.48 ev.

11,767 EFFECTIVE MASS SHIFTS IN CYCLOTRON RESONANCES IN UNIAXIALLY STRESSED SILICON by J.C. Hensel (Bell Labs.); Bull. Am. Phys. Soc., Ser. II, Vol. 6, p. 304(A), Apr. 24, 1961

Cyclotron resonance observations of shifts of effective mass with changes of stress in the valence bands of Si split by uniaxial stress were reported. The experiments were done at ~9000 Mc and at 1.26°K on 5000 ohm-cm p-type samples subjected to uniaxial stresses up to 2200 kg/cm^2. Using white tungsten light to generate carriers, the stress-induced shifts were found to be $\Delta m_\perp/\Delta T = +0.94 \times 10^{-6}\ cm^2/kg$ and $\Delta m_\parallel/\Delta T = -3.4 \times 10^{-6}\ cm^2/kg$ for stress T along the [001] axis, and $\Delta m_\perp/\Delta T = +22.9 \times 10^{-6}$ cm^2/kg and $\Delta m_\parallel/\Delta T = -8.25 \times 10^{-6}\ cm^2/kg$ for stress along the [111] axis. Extrapolation to zero stress gives the effective masses $m_\perp = 0.2612 \pm 0.0002$, $m_\parallel = 0.2010 \pm 0.0005$, and $m_\perp = 0.3780 \pm 0.0005$, $m_\parallel = 0.1412 \pm 0.0005$ for the [001] and [111] cases, respectively. The revised values for the valence-band inverse mass parameters are, accordingly, (in units of $\hbar^2/2m$) $A = -4.21 \pm 0.01$ and $|B| = 0.86 \pm 0.02$ from the [001] case, and $A = -4.13 \pm 0.01$ and $|N| = 8.87 \pm 0.04$ from the [111] case. Additional small line shifts are found to arise from

the spectral distribution of the illumination. Measurements with monochromatic light show a decrease in the cyclotron mass for radiation near the band gap. This effect may be responsible for the remaining difference between the above quoted values for A.

Transverse and Ellipsoid Effective Mass in PbTe - See 11,887

11,768 CORRELATION BETWEEN MOBILITY AND EFFECTIVE MASS IN SEMICONDUCTORS by R.W. Keyes (Westinghouse); J. Appl. Phys., Vol. 30, p. 454(L), Mar. 1959

By use of measured values of μ_L, the lattice scattering mobility at 300°K, and m*, the effective mass, a relationship between these two parameters is derived. μ_L varies approximately as $m^{*-1.35}$. The data can also be roughly represented by $\mu_L \sim m^{*-1}$. As the measured mobility values vary over two orders of magnitude, the relaxation time to which it is related varies only by a factor of four.

11,769 HALL MOBILITY OF THE SMALL POLARON by L. Friedman and T. Holstein (U. Pittsburgh); Bull. Am. Phys. Soc., Ser. II, Vol. 6, p. 302-303(A), Apr. 24, 1961

The Hall mobility of polarons in insulators was discussed. If the conduction bandwidth is sufficiently narrow, an excess electron tends to get trapped at atomic sites by self-induced lattice distortion. Thermal vibrations give rise to jumps between two such sites by causing momentary coincidences of electronic energies, thereby allowing the electronic-overlap jump mechanism to become operative. A modification of the elementary jump probability by an applied magnetic field occurs for those events in which the energies of three sites are simultaneously coincident. The effect arises from the interference between the amplitude for the first-order jump between two sites and that for a second-order jump involving intermediate occupancy of the third site. For H = 0, the two amplitudes are 90° out of phase and do not interfere; for H = 0, the phase difference is altered by an amount proportional to the magnetic flux enclosed by the triangle defined by the site centroids. The resulting Hall mobility is found to be greater than or comparable to the normal value, according to whether or not the three sites are mutually nearest neighbors.

11,770 PHOTOCONDUCTIVE HALL EFFECT IN POTASSIUM BROMIDE by M. Onuki (Osaka City U.); J. Phys. Soc. Japan, Vol. 16, pp. 981-988, May 1961

Measurements of the mobility of conduction electrons in KBr under space charge free conditions in an ac field at temperatures between 80°K and room temperature are reported. White light was used to illuminate the specimen to enhance the conductivity. The mobility, which depends on temperature, was found to be inversely proportional to the mean density of phonons excited in the crystal. This fact suggests that the mobility is determined mainly by the scattering of the optical mode of lattice vibration. Using the Low and Pines formula, the following values were obtained: (1) effective mass of the bare conduction electron, $m^* = 0.23\ m$, where m is the free electron mass; (2) effective mass of the polaron, $m_p = 0.33\ m$; (3) strength of interaction between the electron and the polarization, $\alpha = 2.56$.

11,771 AN ALTERNATIVE APPROACH TO THE SOLUTION OF ADDED CARRIER TRANSPORT PROBLEMS IN SEMICONDUCTORS by J.P. McKelvey, T.P. Brody, and R.L. Longini (Westinghouse Res. Labs.); Bull. Am. Phys. Soc., Ser. II, Vol. 6, p. 28(A), Feb. 1, 1961

A method of solving added carrier transport problems in semiconductors was described. The usual procedure in treating such problems is to derive a continuity equation for carrier concentration (assuming carrier conservation after allowing for generation and recombination) and to solve this equation under appropriate boundary conditions. Net fluxes are obtained from diffusion and drift current equations which involve concentrations and gradients. In the new formulation, equations embodying flux conservation (again allowing for generation and recombination), which incorporate boundary conditions from the outset, are solved in the steady-state, one-dimensional case, giving a Green's function for the desired carrier flux directly. The method is more general than the continuity equation formulation in that the dimensions of the system and the diffusion lengths need not be large compared to the mean free path; in particular, it is unnecessary to assume Fick's law for diffusion. Otherwise, the method is equivalent to the continuity equation analysis. An example involving carrier generation in a region bounded by a plane surface of arbitrary reflection coefficient (recombination velocity) and by a parallel collecting junction was worked out.

11,772 DERIVATION OF THE BOLTZMANN TRANSPORT EQUATION FOR INELASTIC COLLISIONS by P.N. Argyres (Lincoln Lab.); J. Phys. Chem. Solids, Vol. 19, pp. 66-72, Apr. 1961

A quantum-mechanical derivation of the Boltzmann transport equation for inelastic collisions is given along the lines Kohn and Luttinger have developed for elastic collisions. It is shown that for Fermi-Dirac particles the scattering in the collision term of the transport equation is restricted to unoccupied states only, in contradistinction to the case of elastic collisions.

11,773 A STUDY OF ENERGY-LOSS PROCESSES IN GERMANIUM AT HIGH ELECTRIC FIELDS USING MICROWAVE TECHNIQUES by A.F. Gibson, J.W. Granville, and E.G.S. Paige (Roy. Radar Estab.); J. Phys. Chem. Solids, Vol. 19, pp. 198-217, May 1961

Room temperature measurements of the absorption and phase shift of microwaves (34.75 kMc) in germanium to which a high electrical field is applied are reported. The mobility and dielectric constant have been deduced from these measurements and it was found that (1) the mobility at the microwave frequency is intermediate between the mobility (V/E) and the slope mobility (dV/dE) obtained from the variation of carrier velocity with electric field, and (2) the contribution of the free carriers to the dielectric constant is negative at zero field but becomes positive for high electric fields. These effects have been interpreted in terms of an energy relaxation process. A theory of mobility and dielectric constant under the conditions of the experiment is developed. From the dielectric constant data at zero field an effective mass is deduced. For electrons the comparison of this mass with the conductivity mass reveals no increase between 4° and 300°K within the experimental error (15 per cent). For holes evidence that the relaxation times of light and heavy holes are not identical at 300°K and that there is a significant increase in the effective mass between 4° and 300°K is presented.

11,774 n-DIFFUSION by J.R. Philip (CSIRO); Austl. J. Phys. Vol. 14, pp. 1-13, Mar. 1961

Transfer processes in which an entity is transferred down a gradient of a concentration-like quantity to satisfy the relation $\vec{q} = -\vec{A}\cdot\vec{B}$, with $\vec{q}$ the flux density, $\vec{A}$ dependent on time, concentration and position, and $\vec{B}$ a function of the concentration gradient, $\nabla\theta$ are discussed. In ordinary diffusion $\vec{B} = \nabla\theta$. The more general transfer process, designated n-diffusion, for which $\vec{B} = |\nabla\theta|^{n-1}\nabla\theta (n > 0)$ are considered in this paper. The simplest unsteady one-dimensional problem of n-diffusion (with $\vec{A}$ constant) into a semi-infinite region is treated. The results are extended to the related problem in the (doubly) infinite region. Solutions are found in terms of the incomplete beta-function, though for certain values of n, solutions are expressible in terms of elementary functions. Infinite "tails" (analogous to that in one-diffusion) occur for $0 < n < 1$, while the concentration profiles are finite for $n > 1$. Distance of penetration into the region and cumulated flux vary as $(\text{time})^{1/(n+1)}$. This paper is intended as an introduction to later work on concentration- and space-dependent forms of n-diffusion which are immediately relevant to physical problems of interest.

11,775 INVESTIGATIONS ON THE DIFFUSION OF MINORITY CARRIERS FROM A POINT ON SILICON by C.H. Champness (Northern Elect.); Can. J. Phys., Vol. 39, pp. 754-767, May 1961

The field-free diffusion of minority carriers injected at a point in silicon and the time from injection to the maximum of the collector signal due to the arriving carriers measured for various emitter-collector distances are discussed. It was found that for 2 ohm-cm, 6 μsec, n-type material the time to maximum was approximately proportional to the emitter-collector spacing raised to the power 1.2 for flat surfaces and to the power 1.6 for 3- and 6-degree wedge samples. The power 1.6 was also found for a 17-degree wedge of 120 ohm-cm, 100 μsec, p-type silicon. Decay times following the maxima appeared to increase with emitter-collector spacing. No adequate two-surface theory is available but comparison with a one-surface theory revealed serious disagreements. It appears that the results may be explained qualitatively by assuming that the effective lifetime is dependent on the excess carrier density and decreases as the emitter point is approached.

Carrier Properties of $A^{II}B^{VI}$ Compounds - See 11,730

CONDUCTIVITY (RESISTIVITY)

11,776 TEMPERATURE DEPENDENCE OF ELECTRICAL RESISTANCE OF THIN METAL FILMS IN DIFFERENT ENVIRONMENTS by H. Schwarz (RCA); Bull. Am. Phys. Soc., Ser. II, Vol. 6, p. 243(A), Apr. 24, 1961

Results of measurements on the resistance of vacuum-deposited thin-metal films as a function of temperature in vacuum, air, argon, and silicone oil were discussed. The films were formed by the deposition of a nickel-chromium alloy on ceramic substrates. Measurements were made of uncoated films and of films which were coated with a protective layer of silicone monoxide in the thickness from 5,000 to 10,000 A. When measured under vacuum, resistors displayed a temperature coefficient of resistance lower than that obtained in air, argon, or silicone oil. In an argon environment, the films had lower coefficients of resistance than in air or silicone oil. Even when the metal films were protected by a 10,000 A layer of silicon monoxide, their temperature-coefficient behavior differed in different gas environments. Most of the temperature coefficients measured in the temperature range from -55° to +150°C were between 5 and 50 parts per million per degree centigrade.

Measurement of Conductivity - See 11,928

11,777 AN AC BRIDGE FOR SEMICONDUCTOR RESISTIVITY MEASUREMENTS USING A FOUR-POINT PROBE by M. A. Logan (Bell Labs.); Bell Sys. Tech. J., Vol. 40, pp. 885-919, May 1961

A direct-reading ac bridge circuit which measures semiconductor bulk and sheet resistivity using a four-point or other appropriate probe is described. The range of resistivity which can be measured is from 0.001 to 10,000 ohm-cm. Resistivity is read directly from resistance decades and a ratio multiplier, eliminating voltmeter and ammeter errors. The final reading is the result of a bridge-balancing operation for each measurement. Stability and sensitivity provide better than 0.5 per cent electrical accuracy, with mechanical point spacing being the controlling limitation on the overall accuracy of the measurement. The use of ac eliminates the influence of rectification, thermal, or contact potentials on the measurements, and also provides sensitivity more readily than with dc. The four-point probe and test specimen are the only nongrounded elements. An appendix compiles four-point probe conversion factors for thin circular and rectangular slices of material. New tables are presented for slices having an everywhere continuous diffused skin, and thus also conducting across the back.

11,778 A NEW METHOD FOR MEASURING THE VOLUME RESISTIVITY OF SEMICONDUCTOR MATERIAL by G.L. Allerton and J.R. Seifert (Western Elect.); Semicon. Prod., Vol. 4, pp. 43-44, June 1961

A microwave technique for measuring the resistivity of semiconducting material is described. A slice of the sample is used to load a high Q transmission type cavity resonant at 9 kMc. A signal transmitted through the cavity is attenuated as the sample resistivity increases. The advantages of this system are: accuracy, speed, confinement to a depth dependent upon frequency and elimination of surface damage caused by four point probing.

Effects of Radiation on Conductivity in Solids - See 11,911

11,779 LOW-FREQUENCY CONDUCTIVITY DUE TO HOPPING PROCESSES IN SILICON by M. Pollak and T.H. Geballe (Bell Labs.); Phys. Rev., Vol. 122, pp. 1742-1753, June 15, 1961

Measurements of the complex conductivity of n-type Si with various kinds of impurities at frequencies between 10^2 and 10^5 cps and temperatures between 1° and 20°K are reported. In most cases it is orders of magnitude larger than the measured dc conductivity; this is attributed to polarization caused by hopping processes. The observed frequency dependence in the measured range can be expressed as $A\omega^{0.8}$, where A is a complex constant. At the low-temperature end the conductivity is roughly proportional to minority impurity concentration and is almost independent of the majority impurity concentration; at higher temperatures the conductivity becomes approximately proportional to the product of both concentrations. A simple theory, based on the currently accepted model of impurity conduction, is given for the higher temperature range. It accounts

for the observed frequency and concentration dependences, but only order-of-magnitude absolute agreement is obtained.

11,780 EFFECT OF PLASTIC DEFORMATION ON THE LOW-TEMPERATURE IONIC CONDUCTIVITY OF POTASSIUM CHLORIDE by B.S.H. Royce and R. Smoluchowski (Princeton U.); Phys. Rev., Vol. 122, pp. 1125-1128, May 15, 1961

Measurements of the ionic conductivity of KCl in the temperature range between 25° and 250°C were reported. Both "as received" crystals and specimens having up to 24 per cent plastic deformation were examined and the activation energies for ionic motion were determined. It was found that up to 4 per cent plastic deformation produced no change in the activation energy compared with the "as received" specimens, whereas deformations above 10 per cent produced a decrease of about 0.2 ev. After such deformation, structure normally present in the ln (IT) vs T^{-1} plot is absent and the decrease in activation energy can be attributed to the generation of ion vacancies not associated with divalent impurities. Measurements on a deformed and annealed specimen support this view.

11,781 DETERMINATION OF RESISTIVITY TENSOR AND HALL TENSOR OF ANISOTROPIC CONDUCTORS by L.J. van der Pauw (Philips); Philips Res. Rep., Vol. 16, pp. 187-195, Apr. 1961

Resistivity and Hall effect tensors of anisotropic conductors are discussed. The resistivity tensor with respect to an arbitrarily chosen rectangular coordinate system can be described by six constants. It is shown that these six constants are related to the "sheet resistivities" of six plane-parallel samples by six linear equations. The plane-parallel samples may be of arbitrary shape and cut in arbitrary but known directions. The Hall effect can most generally be described by nine constants. For the determination of these nine constants only three such samples are required when combined with three different orientations of the magnetic induction.

11,782 DEVIATIONS FROM OHM'S LAW IN GERMANIUM AND SILICON by M.A.C.S. Brown (Roy. Radar Estab.); J. Phys. Chem. Solids, Vol. 19, pp. 218-227, May 1961

Measurement of the deviation from Ohm's law in Ge and Si at high electric fields by a microwave method at room temperature is reported. It has been found that this deviation depends on the type and resistivity of the material, and also on the orientation of the electric field with respect to the crystallographic axis. Small deviations from the well-known quadratic variation with electric field have been observed. The quantity measured has been related to the steady-state deviation from Ohm's law by an expression involving the energy relaxation time of the carriers and the period of the microwave frequency used. Agreement with the experimental values for the steady-state deviation from Ohm's law has been obtained by using a theory which considers scattering by both acoustical and optical modes, combined with a postulated increase in the effective masses of the free carriers.

11,783 RESISTIVITY OF DIAMOND AT ROOM TEMPERATURE by J.A. Elmgren and D.E. Hudson (Iowa State U. and Ames Lab., U.S. AEC); Bull. Am. Phys. Soc., Ser. II, Vol. 6, p. 303(A), Apr. 24, 1961

The resistivity of diamond (Type I or Type IIa) is usually quoted as 10^{14} - 10^{16} ohm cm, but very little reliable experimental work is reported to support the values. Measurements of the rate of decay of persistent polarization of diamond in the dark have been made by a counting experiment. The method is one which measures primarily the bulk resistivity rather than surface effects. The results lead to the conclusion that the diamonds under investigation have bulk resistivities of the order of 10^{19} ohm cm or higher, at 25°C. Resistivities of this order are in more reasonable agreement with theoretical calculations based on the activation energies of imperfection systems observed by optical absorption techniques.

11,784 ELECTRICAL CONDUCTIVITY AND THERMOELECTRIC POWER OF CALCIUM OXIDE by C.H.B. Mee (U. Southampton); Nature, Vol. 190, pp. 1093-1094(L), June 17, 1961

The electrical conductivity of calcium oxide is discussed. Measurements were made in an experimental arrangement in which a 100 μ layer of the oxide was placed between two nickel cathode buttons. Each button had an independent heat source and the temperature was determined with a tungsten-nickel thermocouple. The electrical conductivity σ was measured as a function of temperature T log σ as plotted vs 1/T. Two linear portions occur, one up to 800°K and another from 800° to 1000°K; these are explained in the first case by semiconduction over crystallite faces, and in the second by thermionic electron emission. Activation energies agree reasonably with values obtained by Hopkins and Vick. The thermoelectric power of the oxide was also measured. If the buttons are maintained at different temperatures, a thermoelectric EMF is set up between the faces which may be measured with a vibrating condenser electrometer. It is found that the EMF is approximately proportional to the temperature between the buttons.

11,785 ELECTRICAL RESISTIVITY CHANGES IN ANNEALED Cu_3Au ABOVE THE CRITICAL TEMPERATURE by A.C. Damask, Z.A. Fuhrman, and E. Germagnoli (Cent. Info. Studio Experienze, Milan); J. Phys. Chem. Solids, Vol. 19, pp. 265-280, May 1961

Changes in the electrical resistivity of Cu_3Au which occur above the critical temperature, both at temperature and after quenching are discussed. In general it has been found that several hours are required to establish a new equilibrium resistivity, and that this time varies only by a factor of about three over the range T_c to 700°C. The rates of change at temperature are for the most part exponential, and a low for the behavior has been obtained. The changes occurring after quenching are much more complex. When the temperature is increased and an isothermal curve is obtained by quenching the wire after each time at temperature, there is a sudden increase of resistivity followed by a monotonic decrease. When the temperature is lowered, only a monotonic decrease is observed. These curves do not fit any simple kinetic equation. The final values of these resistivities obtained from the quenching data give two equilibrium states of resistivity, and a transition between them is observed at 600°C as suggested by other experimenters. When the lower of these two equilibrium resistivity states is established, there is no longer a discontinuity in the electrical resistivity when the critical temperature is crossed. However, only a single equilibrium state of resistivity was observed at temperature. Some possible effects of quenching are discussed.

11,786 ELECTRICAL CONDUCTIVITY AND THERMOELECTRIC EFFECT IN SINGLE-CRYSTAL TiC by L.E. Hollander, Jr. (Lockheed); J. Appl. Phys., Vol. 32, pp. 996-997, June 1961

CONDUCTIVITY (RESISTIVITY) (Cont'd)

Measurements of the temperature dependence of resistivity, thermoelectric power, and hydrostatic piezoresistivity on TiC single crystals are reported. The resistivity of all samples was 200 ± 20 μohm-cm and is affected by at least three factors: nonstoichiometric composition, effects of oxygen in the lattice, and stress concentrations. The thermoelectric power $\Delta V/\Delta T$ referenced against Cu at room temperature is 7.8 ± 0.6 μv/°C and indicates n-type conduction. No hydrostatic piezoresistivity was observed. P vs T and thermoelectric data indicate that single crystal TiC has metallic-type conduction and that the predominant charge carriers are electrons.

11,787 THE ELECTRICAL RESISTIVITY OF $ZrZn_2$ by C.E. Olsen (U. California); J. Phys. Chem. Solids, Vol. 19, pp. 228-229, May 1961

Electrical resistivity measurements on the ferromagnetic intermetallic compound $ZrZn_2$ between 2.2° and 295°K are discussed. They fail to show an anomaly at the ferromagnetic transition such as are observed in other ferromagnetic elements and compounds. A possible mechanism for this behavior is considered.

SUPERCONDUCTIVITY

11,788 SUPERCONDUCTIVE PROPERTIES OF THIN TIN FILMS by E.C. Crittenden, Jr., J.N. Cooper, and F.W. Schmidlin (Space Tech. Labs.); U.S. Gov. Res. Rep., Vol. 35, p. 797(A), June 16, 1961 PB 154 232

The superconductive properties of a carefully prepared family of 8 thin Sn films with thicknesses varying from 0.03 to 1.04 μ between 1.5° and 3.9°K were discussed. The films were prepared by vacuum evaporation upon polished glass substrates cooled to -20°C. Film thicknesses were measured by Fabry-Perot interferometry and were also calculated both from mass evaporated and from resistance measurements. Critical temperatures, particularly for the thinner films, were substantially above that for bulk Sn, presumably because of tensile stresses. The dc critical currents as a function of thickness t can be well approximated by an expression of the form $A(1-f(x))/(1+f(x))$, where A is a constant determined by the temperature and χ is essentially independent of temperature.

11,789 SUPERCONDUCTING CHARACTERISTICS OF SUPERIMPOSED METAL FILMS by P.H. Smith, S. Shapiro, J.L. Miles, and J. Nicol (A.D. Little); Phys. Rev. Lett., Vol. 6, pp. 686-688(L), June 15, 1961

The electrical properties of superimposed films of superconductors and normal metals have been examined by the techniques of resistance measurement, persistent currents, and electron tunneling. The results indicate that the normal metal (e.g., Ag in a Ag-Pb pair) does become superconducting and that the system behaves as a superconductor does, with a transition temperature determined both by the constituent materials and by their relative thicknesses. It is argued that the observations are not due to alloying, diffusion, or similar effects. The experiments are compared with those of Meissner on the contact resistance between crossed plated wires of normal and superconducting metals. Measurements of resistance, critical temperature, critical current, and critical field vs temperature were made; the measuring techniques are described in detail. The reported results indicate that a pure, normal state metal film in immediate contact with a film of a superconductor will depress the transition temperature of the superconductor, the depression being greater for increasing thickness of the normal metal. When a film of a normal conductor is placed in direct contact with a film of a superconductor, the combination exhibits the attributes of a superconductor, including the ability to pass a supercurrent through the otherwise normal metal and the presence of an energy gap throughout the sample.

11,790 AN UPPER LIMIT FOR THE RESISTIVITY OF A SUPERCONDUCTING FILM by R.F. Broom (Services Electronics Res. Lab.); Nature, Vol. 190, p. 992(L), June 10, 1961

An experiment to determine whether the resistance of a conducting film of thickness comparable to the depth of penetration is truly zero is described. A lead film was evaporated onto a glass substrate. This was covered with a silicon insulator and a thin film of a lead alloy was deposited over the insulator making contact with the lead at both ends. A current was induced in the loop and the magnetic field was measured with a bismuth Hall-effect probe. The arrangement made the L/R time small and so increased the sensitivity of the measurements. A decay in the field would indicate the presence of resistance. The accuracy of measurement was 1 part in 50, but no current decay outside this limit was observed. The resistivity in the superconducting state was less than 10^{-21} ohm-cm, which is close to the upper limit obtained by Collins.

11,791 CURRENT DISTRIBUTIONS IN THIN SUPERCONDUCTING FILMS by P.M. Marcus (IBM Res. Ctr.); Bull. Am. Phys. Soc., Ser. II, Vol. 6, p. 267(A), Apr. 24, 1961

Detailed solutions have been obtained for current distributions within, and the magnetic fields in and around, a superconducting film of rectangular cross section carrying a steady current when the London constitutive equation for a superconductor is satisfied. The problem has been attacked through the inhomogeneous linear integral equation over the cross section for the current density. By power series expansion in the thickness coordinate, the problem is reduced to a series of coupled integral equations in one coordinate, which are then solved by systematic approximation by sets of linear equations. The cases of interest consider films of thickness t comparable to the penetration depth λ and widths w up to 500 λ or more. The current distributions are then fairly uniform through the thickness, but very sharply peaked at the edges, and fall off slowly toward a minimum value at the center; the ratio of the center value to the edge value varies approximately as $1/(wt)^{\frac{1}{2}}$ and is 0.075 for $w = 500\ \lambda$, $t = \lambda$. The effects of a ground plane of external magnetic fields, and of nonlocal constitutive equations are also being studied.

11,792 DEVIATIONS FROM THE LAW OF CORRESPONDING STATES IN THE THEORY OF SUPERCONDUCTIVITY by J.C. Swihart (IBM Res. Ctr.); Bull. Am. Phys. Soc., Ser. II, Vol. 6, p. 267(A), Apr. 24, 1961

The BCS integral equation for various nonseparable interactions $V_{kk'} = V(|\epsilon_k - \epsilon_{k'}|)$ was discussed. Numerical solutions have been obtained on an IBM 704 for the energy-gap function $\Delta_k(T)$ for a square well potential V(x) which is attractive for $x < \frac{1}{2}\theta_D$, repulsive for $\frac{1}{2}\theta_D < x < x_1$, and zero for $x > x_1$. The cutoff x_1 is arbitrarily taken between θ_D and $2\theta_D$. The ratio $\eta \equiv 2\Delta_{kF}/kT_c$ is rather insensitive to the various parameters for several cases tried, giving nearly the original BCS value of 3.5. This shows that the BCS theory does give the law of corresponding states. In one case, to simulate Pb or Hg, a potential was

taken with the repulsive part equal to the average Coulomb interaction, while the attractive part was chosen to give a T_c of 7.3° with $\theta_D = 70°$. For this strong coupling case, η was raised to 4.01. This solution gives for the jump in the specific heat at T_c the value 1.51 compared to 1.40 for BCS.

11,793 NEUTRON SCATTERING BY CONDUCTION ELECTRONS AS A PROBE OF THE SUPERCONDUCTIVITY ENERGY GAP by W.H. Lupton and R.A. Ferrell (U. Maryland); Bull. Am. Phys. Soc., Ser. II, Vol. 6, p. 262(A), Apr. 24, 1961

Inealstic scattering of neutrons by the conduction electrons in a metal was discussed. The scattering reveals a cross section that is peaked in the forward direction due to the interaction of the neutron magnetic moment with the electronic currents. A phenomenological treatment shows that the cross section is related to the frequency and wave number-dependent conductivity. A degenerate electron gas is used as a model for the normal state of a metal. In a superconductor an electron must receive enough energy to surmount the energy gap, hence the small angle cross section is reduced. The ratio of the cross sections in the superconducting and normal states has been estimated from the conductivity reported by Glover and Tinkham. The scattering by the nuclei of the crystal lattice was also analyzed since it would be an important competing process in a proposed experiment.

Phase Transitions in Superconductors - See 11,748

11,794 EFFECT OF DISSOLVED GASES ON SOME SUPERCONDUCTING PROPERTIES OF NIOBIUM by W. DeSorbo and G.E. Nichols (GE Res. Lab.); Bull. Am. Phys. Soc., Ser. II, Vol. 6, p. 267(A), Apr. 24, 1961

Measurements of the superconducting resistance transition characteristics of wire specimens of Nb containing various dissolved gases, i.e., oxygen, nitrogen, hydrogen, and deuterium, in a longitudinal magnetic field were reported. Before the addition of the gases, the wires, made from an electron beam melted stock, were annealed and "degassed" in a high vacuum ($1 < 1 \times 10^{-6}$ mm of Hg) and high temperatures (1800° - 2000°K). For a specimen with a resistance ratio equal to ~ 500, T_c = 9.465°K, whereas, prior to the thermal treatment, T_c = 9.668°K. These are in good agreement with T_c values recently reported. The initial slope of the critical magnetic field, $(\partial H_c/\partial T)_i$, is 530 oe/deg after the thermal treatment, and 1140 oe/deg prior to it. Oxygen has the largest effect on T_c and on the noncontinuous behavior of the transition. The addition of small amounts decreases T_c and increases $(\partial H_c/\partial T)_i$, e.g., for specimen containing 1.4 at. per cent, T_c = 5.840°K, $(\partial H_c/\partial T)_i$ = 5000 oe/deg. The addition of oxygen in larger amounts increases T_c again while $(\partial H_c/\partial T)_i$ decreases. The cryostat which renders temperatures reproducible to 1 millidegree was described.

11,795 FIRST AND SECOND ORDER STRESS EFFECTS ON SUPERCONDUCTING TRANSITIONS IN Ta AND Sn by D.P. Seraphim and P.M. Marcus (IBM); Phys. Rev. Lett., Vol. 6, pp. 680-682(L), June 15, 1961

Two very pure <110> single crystals of Ta have been examined for ΔH_c, the change in critical field shift, for uniaxial stresses up to 6000 atm. The crystals clearly exhibit both first and second order stress effects. For tetragonal crystals, the linear terms of ΔH_c involve two parameters, namely:

$$\Delta H_c = \beta_1 (\sigma_1 + \sigma_2) + \beta_3 \sigma_3,$$

where the σ_i are stress orientations. ΔH_c measurements on two crystals of β-Sn, each with the diad axis along the cylinder, at uniaxial stresses up to 200 atm and at temperatures near transition temperature are described. An explanation of the large anisotropy of uniaxial stress ($\beta_3/\beta_1 = 77$) is given. It is noted that ΔH_c vanishes for shear stresses in the basal plane and for stresses with the tetrad axis as one of the two shear-defining directions, though not for all shear stresses.

11,796 KAPITZA BOUNDARY RESISTANCE BETWEEN NORMAL AND SUPERCONDUCTING TIN AND LIQUID HELIUM by J.I. Gittleman (RCA Labs.); Bull. Am. Phys. Soc., Ser. II, Vol. 6, p. 268(A), Apr. 24, 1961

Measurements of the Kapitza boundary resistance between liquid helium and tin in the temperature range from 1.4° to 2.0°K were reported. The Kapitza resistance was found to vary as T^{-3} in this range, as would be expected from the work of Khalatnikov and Little. A 9 per cent increase was noted when the tin was in the superconducting state compared to its value when it was normal. This is contrary to measurements reported by Challis for lead, which showed that the Kapitza resistance in the same temperature range was nearly three times larger for lead in the superconducting state than in the normal state. Although the reason for the difference between the results for lead and tin is not known, it is probably related to the fact that the Debye temperature of tin is much higher than for lead. Thus, in lead the lattice dominates the thermal properties, whereas in tin the electrons contribute strongly. Measurements on indium, which has a Debye temperature slightly higher than that of lead, have also been made. The Kapitza resistance in the normal state measures slightly less than in the superconducting state.

11,797 SIMPLE MODEL FOR THE MAGNETIC BEHAVIOR OF SUPERCONDUCTORS OF NEGATIVE SURFACE ENERGY by B.B. Goodman (Inst. Fourier); Phys. Rev. Lett., Vol. 6, pp. 597-599(L), June 1, 1961

A model representing a type of magnetic behavior characteristic of homogeneous strain-free superconductors of negative surface energy is described. A superconductor of negligible demagnetizing coefficient is divided, in the presence of a magnetic field, into thin normal superconducting laminas each obeying the London equation. The model compares well with experimental magnetization curves. The magnetic field needed for complete suppression of superconductivity appears as a true thermodynamic variable, rather than as a property associated with certain individual lattice flaws. The persistence of superconductivity in high magnetic fields, due to the existence of a negative surface energy, should be favored by a short electronic mean free path, and thus a high resistivity, in the normal state.

11,798 MAGNETIC FIELD DEPENDENCE OF THE SUPERCONDUCTING ENERGY GAP AND PENETRATION DEPTH by D.H. Douglass, Jr. (Lincoln Lab.); Bull Am. Phys. Soc., Ser. II, Vol. 6, p. 267(A), Apr. 24, 1961

Gor'kov has recently derived the Ginzburg-Landau (GL) phenomenological equations of superconductivity from the microscopic theory in the region where $T_c - T \ll T_c$ and $\xi \ll \lambda(T)$, where ξ is the coherence length and $\lambda(T)$ is the penetration depth. He has shown that the order parameter ψ of the GL theory is directly proportional to the energy gap. In the GL theory,

ψ is a function of temperature and field, and is identified with the penetration depth. Thus, the field dependence of the energy gap and penetration depth can be obtained by solving the GL equations for $\psi(H)$. This has been done for a superconducting plate. The results show that the maximum effect occurs for thin specimens. For very thin plates, $[\lambda(T,0)/(T,H)]^2 = 1 - (H/H_c)^2$, $[\epsilon(T,H)/\epsilon(T,0)]^2 = 1 - (H/H_c)^2$, where ϵ is the energy gap and H_c is the critical field of the plate.

11,799 SUPERCONDUCTING FILM GEOMETRY WITH STRONG CRITICAL CURRENT ASYMMETRY by H.H. Edwards and V.L. Newhouse (GE Res. Lab.); Bull. Am. Phys. Soc., Ser. II, Vol. 6, p. 267(A), Apr. 24, 1961

It was shown that film critical current, defined as the maximum current for which the film shows no resistance, can be strongly increased in one direction and strongly decreased in the other by the field from two current-carrying wires placed parallel to the film edges. The increase in critical current was shown to be associated with a mutual cancellation of the normal magnetic fields created by the wire currents and the film current. This cancellation occurs when the film current is uniformly distributed. This fact causes a uniform current distribution to occur. Experimental evidence was presented to show that the symmetrical increase of critical current due to the proximity of a superconducting "shield" plane is the result of the same mechanism. Fields normal to the film surface also may be largely responsible for the broad current-induced transition of flat "unshielded" films. With mutually opposed wire currents, the variation of critical current with wire current exhibits a significant hysteresis.

11,800 STUDY OF SUPERCONDUCTORS BY ELECTRON TUNNELING by I. Giaever and K. Megerle (GE Res. Lab.); Phys. Rev., Vol. 122, pp. 1101-1111, May 15, 1961

Energy gap studies employing tunneling are discussed. If a small potential difference is applied between two metals separated by a thin insulating film, a current will flow due to the quantum mechanical tunneling effect. If both metals are in the normal state, the current-voltage characteristic is linear; if one of the metals is in the superconducting state, the current-voltage characteristic becomes nonlinear; and if both metals are in the superconductive state even a negative-resistance region is obtained. From these changes in the current voltage characteristics, the change in the electron density of states when a metal goes from its normal to its superconductive state can be inferred. The energy gap in metal films 1000 - 3000 A thick at 1°K has been found to be $2\epsilon_{Pb} = (2.68 \pm 0.06) \times 10^{-3}$ ev, $2\epsilon_{Sn} = (1.11 \pm 0.03) \times 10^{-3} \times 10^{-3}$ ev, $2\epsilon_{In} = (1.05 \pm 0.03) \times 10^{-3}$ ev, and $2\epsilon_{Al} = (0.32 \pm 0.03) \times 10^{-3}$ ev. The variation of the gap width with temperature is found to agree closely with the Bardeen-Cooper-Schrieffer theory. Furthermore, the energy gap in these films has been found to depend upon the applied magnetic field, decreasing with increasing field.

11,801 SUPERCONDUCTIVITY IN THE σ and α-Mn STRUCTURES by R.D. Blaugher and J.K. Hulm (Westinghouse Res. Labs.); J. Phys. Chem. Solids, Vol. 19, pp. 134-138, Apr. 1961

The sigma and alpha-manganese structures formed by binary alloys between the group (V, Nb, Ta, Cr, Mo, W) and the group (Mn, Fe, Co, Ni, Ru, Rh, Pd, Re, Os, Ir, Pt) have been investigated for superconductivity down to 1°K. Nineteen new superconductors were found in these two systems with the majority occurring in the sigma phase. A plot of superconducting transition temperature of the sigma phases against the average number of valence electrons per atom exhibited a maximum at approximately $6\frac{1}{2}$ electrons per atom. This maximum is similar to those found for other structures by Matthias; however it is displaced somewhat from the vicinity of 5 or 7 electrons per atom which Matthias indicated to be characteristic of other systems. The sigma phase data therefore suggests that in compound information between pairs of transition elements, the d-band shape is preserved to some extent and is filled at an intermediate level by the available electrons.

11,802 SUPERCONDUCTIVITY OF Nb_3Sn IN PULSED FIELDS OF 185 KILOGAUSS by V.D. Arp, R.H. Kropschot, and J.H. Wilson (Natl. Bu. Stand.); Phys. Rev. Lett., Vol. 6, pp. 452-453(L), May 1, 1961

Measurements of the critical currents and fields at temperatures between 4° and 1.6°K for a swaged and annealed 0.50 mm Nb_3Sn-Nb clad wire are reported. The wire was held parallel to a pulsed field rising to a peak of 185 kgauss in 7 msec. When extrapolated to negligible measuring current, the critical field of this specimen is found to be 188 kgauss at 1.6°K. An estimate of eddy current heating in the sample during the field pulse indicates that it is measurable but not important. Calculations from the equations given by Kosevitch show that the attenuation through the Nb sheath is of the order of 1 gauss and completely negligible.

Thermal Conductivity of Superconducting Lead Alloys - See 11,926

Thermal Conductivity of Superconducting Sn and In Films - See 11,927

Elastic Moduli of Superconducting Pb, V, and Nb - See 11,940

Young's Modulus for Superconducting In - See 11,941

BREAKDOWN

11,803 DEPENDENCE OF IMPACT IONIZATION BREAKDOWN FIELD ON IMPURITY CONCENTRATION by A.L. McWhorter (Lincoln Lab.); Bull. Am. Phys. Soc., Ser. II, Vol. 6, p. 303(A), Apr. 24, 1961

The dependence of breakdown on the impact ionization of impurities in Ge was discussed. The breakdown field is found experimentally to increase linearly with the (majority) impurity concentration for densities above about $10^{15}/cm^3$, whereas existing theory predicts only a square-root dependence. This discrepancy was resolved by taking into account the inelastic scattering due to electronic excitation of neutral impurities in addition to the usual neutral impurity elastic scattering. Since lattice losses are a negligible drag on the electrons at the high fields encountered, the situation is quite analogous to that in hydrogen gas, where the controlling factor in the ionization rate is normally the number of excitations per ionization, both theory and experiment giving for this ratio the form $A \exp(Bp/E)$, where p is the pressure. Assuming the simple hydrogen-like model for donors and scaling the experimental data for hydrogen accordingly, both the correct magnitude for the breakdown field and the linear dependence on concentration were obtained.

11,804 VOLTAGE DEPENDENCE OF MICROPLASMA DENSITY IN P-N JUNCTIONS IN SILICON by A. Goetzberger and C. Stephens (Shockley); Bull. Am. Phys. Soc., Ser. II, Vol. 6, p. 106(A), Mar. 20, 1961

Measurements of the voltage distribution of breakdown spots in p-n junctions were discussed. A junction in Si which was uniform in its crystallographic properties showed two kinds of microplasmas. One type was characterized by light emission and low breakdown voltage, and the other had less light emission and higher breakdown voltage. Both had a rather broad distribution of breakdown voltages. Samples containing a grain boundary showed only the first kind of microplasmas. The observed effects are in agreement with Shockley's SiO_2 precipitate model of microplasmas.

11,805 BREAKDOWN STRENGTH OF CAESIUM IODIDE by R. Taagepero, R.S. Storey, K.G. McNeill (U. Toronto); Nature, Vol. 190, pp. 994-995(L), June 10, 1961

Measurements of breakdown in CsI are discussed. Two crystals of CsI, 0.01 cm thick and containing 0.1 per cent Th, were studied. A breakdown relationship of $Fa^3 = 20 \pm 3$ was observed (F ≡ breakdown field in mv/cm; a ≡ interionic distance in Angstroms). This relationship compares favorably with studies made by Frantz on halides where $Fa^3 = 28 \pm 25\%$.

11,806 ELECTRIC STRENGTH OF RUTILE SINGLE CRYSTALS by D.A. Powers and I.J.T. Johansen (MIT); J. Appl. Phys., Vol. 32, pp. 1083-1085, June 1961

Measurements of the breakdown strength of rutile crystals $\parallel$ and $\perp$ to the optic axis are reported. The dc breakdown is a thermal process occurring at a power level of 2 kw/cm^3 for the particular sample size and test cell used, with field strengths of 20 kv/cm$_\parallel$ to the axis and 120 kv/cm$_\perp$. Impulse measurements at 1-μsec rise time required special techniques of sample and electrode preparation in order to prevent field distortion and surface breakdown. Breakdown strengths of 570 kv/cm$_\perp$ and 690 kv/cm$_\parallel$ to the optic axis were measured.

MAGNETOELECTRIC (GALVANOMAGNETIC) PROPERTIES

11,807 LONGITUDINAL MAGNETORESISTANCE IN n-TYPE GERMANIUM: EXPERIMENTAL by W.F. Love and W.F. Wei (U. Colorado); Phys. Rev., Vol. 123, pp. 67-73, June 1, 1961

Measurements of the longitudinal magnetoresistance of single crystals of pure and doped n-type Ge oriented in the <100>, <110>, and <111> directions in magnetic fields up to 300 kgauss over the temperature interval 20° - 300°K are analyzed. The magnetoresistance ratio $\rho(H)/\rho(0)$ was found to vary linearly with magnetic field strength in the quantum limit. Magnetoresistance ratios less than one were observed and explained on the basis of the many-valley structure of the conduction band. The saturation of magnetoresistance predicted by classical transport theory was observed at the higher end of the temperature range and used to demonstrate a temperature variation of the anisotropy parameter K.

11,808 MAGNETORESISTANCE OF ORIENTED GRAY TIN SINGLE CRYSTALS by O.N. Tufte and A.W. Ewald (Northwestern U.); Phys. Rev., Vol. 122, pp. 1431-1436, June 1, 1961

An investigation of the electronic band structure of gray tin through magnetoresistance measurements on oriented n- and p-type single crystals at 77°, 195°, and 273°K is reported. From these measurements the low-field magnetoresistance coefficients have been evaluated. Magnetoresistance anisotropy was observed in n-type crystals at 195° and 273°K, but was not observed in either n- or p-type material at 77°K. Two possible explanations for the temperature-dependent anisotropy are proposed. The observed anisotropy satisfies, within experimental uncertainty, the symmetry condition for ellipsoidal energy surfaces located along the [111] directions. Hall and conductivity measurements on samples used in the magnetoresistance study revealed a temperature-dependent mobility ratio greater than unity which supports the assumption that the magnetoresistance anisotropy observed in the intrinsic range should be assigned to the conduction band. Under this assumption and that of isotropy of lattice scattering, a lower limit of 2.3 is found for the electronic effective-mass anisotropy parameter.

11,809 INFRARED RADIATION-INDUCED MAGNETOELECTRIC EFFECT IN SEMICONDUCTORS by L. Wandinger (USASRDL); Bull. Am. Phys. Soc., Ser. II, Vol. 6, p. 304(A), Apr. 24, 1961

A study of the magnetoelectric effect in Ge due to absorption of infrared radiation in the temperature range of 300° to 500°K was reported. Samples of different conductivity type and different impurity content have been irradiated with infrared radiation above 2 μ and a magnetoelectric effect of up to 30 μv at 1000 gauss has been measured. The incident radiation, the observed voltage between the ends of the semiconductor, and the direction of the magnetic field are perpendicular to each other. The experimental apparatus and problems for measuring the effect were discussed. Data on the variation of this effect with carrier type and density as a function of sample temperature were reported. Special arrangements (surface condition of sample, radiation source, etc.) assure that photoconductive, photoelectromagnetic, and Dember effects are negligible in comparison to the new magnetoelectric effect which apparently is caused by lattice absorption of the photons. The relation between this effect and the Nernst effect outside the phonon drag region and other magnetoelectric effects was indicated.

11,810 INFLUENCE OF MAGNETOCONDUCTIVITY DISCONTINUITIES ON GALVANOMAGNETIC EFFECTS IN INDIUM ANTIMONIDE by R.T. Bate, J.C. Bell, and A.C. Beer (Battelle); U.S. Gov. Res. Rep., Vol. 35, p. 626(A), May 16, 1961 PB 153 199

Anomalous galvanomagnetic effects in n-type InSb associated with spatial discontinuities in carrier concentration are discussed. These discontinuities result from anisotropic segregation of impurities during crystal growth. An increase in the magnitude of the Hall coefficient at 20,000 gauss to nearly twice the weak-field value was observed in one case. The magnetoresistance is especially sensitive to inhomogeneities. For an inhomogeneous sample at a particular magnetic field, the measured $\Delta\rho/\rho_0$ may be as much as 100 times larger than that for a homogeneous sample. Negative magnetoresistance has also been observed at room temperature in inhomogeneous samples. All of the above observations are predicted qualitatively by considering a simple model consisting of a long, thin specimen having a discontinuity in resistivity and Hall coefficient in the current direction. The boundary value problem corresponding to this case is solved to predict the electric field and current densities.

MAGNETOELECTRIC (GALVANOMAGNETIC) PROPERTIES (Cont'd)

11,811 BASIC TRANSPORT PHENOMENA IN GERMANIUM AND INDIUM ANTIMONIDE by R.T. Bate, S.E. Miller, and A.C. Beer (Battelle); U.S. Gov. Res. Rep., Vol. 35, p. 626(A), May 16, 1961 PB 171 511

The growth of InSb single crystals and the transport properties of InSb and semiconducting diamond are discussed. Summaries of work in galvanomagnetic effects in InSb, purification and single crystal growth, galvanomagnetic effects in semiconducting diamond, and inhomogeneities and associated galvanomagnetic effects in semiconductions are given.

Magnetoresistance of Ni-Fe Films - See 11,840

Hall Effect Tensor of Anisotropic Conductors - See 11,781

11,812 CYCLOTRON RESONANCE IN BISMUTH. Part II. by J.E. Aubrey (Roy. Soc. Mond Lab., England); J. Phys. Chem. Solids, Vol. 19, pp. 321-330, May 1961

An extension of preliminary work on cyclotron resonance in Bi undertaken to check the detail form proposed for the electron energy band and to look for evidence of resonances from the holes is reported. At high fields ($H \geq 2000$ gauss), the surface resistance, R, is found to pass through a minimum and then to increase with H. This departure from the monotonically decreasing form expected from the theory of Azbel' and Kaner can be explained by the circumstance that at high fields, the radii of the electron orbits become comparable with and eventually smaller than the skin depth; this brings about a change from the anomalous to the classical skin effect regime. Values of the zero field surface resistance support the view that the Fermi surface consists of three electron ellipsoids and a single hole spheroid.

11,813 ULTRASONIC CYCLOTRON RESONANCE IN GALLIUM by B.W. Roberts (GE); Phys. Rev. Lett., Vol. 6, pp. 453-455(L), May 1, 1961

Cyclotron resonance maxima at 35, 17, and 11 oe, observed for longitudinal 115 Mc sound waves traveling along the c_o axis in Ga, are discussed. Thirty maxima, spaced at equal intervals of 1/H, were observed as the electron orbit dimension matched the sonic wavelength. These observations suggest a mean free path in the order of 1 cm at 1.5°K. Information on the Fermi surface for Ga is also given.

11,814 ENERGY INTERCHANGE BETWEEN CYCLOTRON AND SYNCHRONOUS WAVES IN QUADRUPOLAR PUMP FIELDS by E.I. Gordon and A. Ashkin (Bell Labs.); J. Appl. Phys., Vol. 32, pp. 1137-1144, June 1961

Passive coupling of the electron cyclotron and synchronous waves in quadrupolar pump fields is examined. It is shown that sinusoidal energy exchange occurs when the quadrupole field is pumped so that the effective or Doppler-shifted pump frequency, as observed by the drifting beam, equals the electron cyclotron frequency. One fast and one slow wave are coupled when the pump frequency is greater than either of the beam wave frequencies, while two fast or two slow waves are coupled when the pump frequency is less than at least one of the beam wave frequencies. Experimental results confirming these predictions are presented and possible applications are discussed. In addition, it is shown that active coupling of two synchronous waves occurs when the effective pump frequency is zero.

Effective Mass Shifts in Cyclotron Resonances in Stressed Si - See 11,767

ELECTRICAL PROPERTIES OF SURFACES

11,815 TEMPERATURE DEPENDENCE OF THE WORK FUNCTION OF METALS (Mo, Ni) by G. Comsa, A. Gelberg, and B. Iosifescu (Inst. Atomic Phys., Bucharest); Phys. Rev., Vol. 122, pp. 1091-1100, May 15, 1961

Measurements of the temperature coefficient of the work function of polycrystalline Mo and Ni in the temperature ranges 600° - 1100°K and 475° - 1025°K, respectively, using the electron beam method are reported. Special precautions have been taken in order to avoid systematic errors due to the effect of residual gases, of stray magnetic fields, of incorrect temperature measurement, of cathode temperature variations, etc. During determinations made upon Ni surfaces, the terrestrial magnetic field has been compensated. Random error sources have been likewise reduced as much as possible.

11,816 TEMPERATURE DEPENDENCE OF THE WORK FUNCTION OF SEMICONDUCTOR THERMIONIC CATHODES by B. V. Bondarenko (Moscow Inst. Phys. and Tech.); Soviet Phys.-Solid State, Vol. 2, pp. 1916-1925, Mar. 1961

The experimental determination of the temperature dependence of the work function of the metal oxides from the third and fourth group: Sc_2O_3, Y_2O_3, La_2O_3, TiO_2, ZrO_2, HfO_2, and of the tungstates of the metals Ba, Sr, and Ca of the type Me_3WO_6 is discussed. The temperature dependence of the work function is found to be in satisfactory agreement with the theoretically predicted character of the electrochemical potential of semiconductors, and it was found possible to explain a number of discrepancies in the thermoelectric properties of semiconductor cathodes by a simple theory developed in this paper.

11,817 SURFACE CURRENTS IN INVERSION LAYERS ON SEMICONDUCTORS [in German] by E. Groschwitz, E. Hofmeister, and R. Ebhardt (Siemens and Halske); Entwicklungsber. S. and H., Vol. 24, pp. 24-40, June 1961

Numerous theoretical and experimental results describing the structure of the inversion layers and the physical phenomena giving rise to structural changes are given. The current mechanism taking place in inversion layers with applied external potential is derived theoretically by reference to the example of point contact diodes. Experimental results concerning the properties of the characteristic curves of formed point contact diodes are also given. The measured values can be interpreted satisfactorily by using the analytically representable surface currents. The influence of the semiconductor surface and the shape of the formed zone on the rectification effect is investigated quantitatively. For point-contact diodes the surface current determines both the magnitude of the diode current and the shape of the characteristic curve.

11,818 SURFACE POTENTIAL OF SILICON by C.T. Raymo, C.W. Brands, and B. Schwartz (Hughes Semicon.); J. Appl. Phys., Vol. 32, pp. 1165-1166(L), June 1961

Surface potential measurements on Si, made by using the dc field effect, are discussed. The applied field is made sufficiently large such that the conductance minimum is passed. If the sample under investigation is held at a uniform temperature, varying by no more than ± 0.02°C, it is possible to monitor

with good reliability the conductance changes of the specimen. Data are presented for an n-type Si sample in which the field was removed after 10 - 45 sec. From the conductance changes a surface potential of -0.14 ev was calculated. P-type Si as well as low resistivity n-type silicon were used with good success.

11,819 EFFECT OF ADSORBED FILMS ON THE SURFACE POTENTIALS OF METALS BY A RADIOACTIVE ELECTRODE TECHNIQUE by L. Nanis, M. Baruch, and J.H. Schulman (Columbia U.); U.S. Gov. Res. Rep., Vol. 35, pp. 786-787, June 16, 1961 PB 150 864

Measurements of the Pt/Au contact potential in various gas atmospheres are discussed. They indicate that gold flamed under oxidizing conditions is suitable as a substrate for study of reactions with organic over-layers. The Pt/Au potential is changed by water vapor and oxygen adsorption, chiefly on Pt. For over-layers of long chain organic compounds dissolved in nonpolar medium, potential changes can be due to reaction at the metal-oil interface or the oil-gas interface, especially where solubility of water is possible.

OTHER ELECTRICAL PROPERTIES

11,820 THEORY OF MICROPLASMA INSTABILITY IN SILICON by R.J. McIntyre (RCA Ltd.); J. Appl. Phys., Vol. 32, pp. 983-995, June 1961

A statistical theory on microplasma instability at the onset of avalanche in reverse-biased Si linearly graded and step junctions is developed. An expression which relates the turn-off probability of the microplasma to the differential resistance of the diode in its conducting state and to other physically measurable diode parameters is derived. Measurements of the turn-off probability as a function of the pulse current are presented for several diodes and are shown to agree well with the derived theory. To explain the turn-on probability, three expressions (each involving slightly different approximations) are derived for the probability that a carrier entering the breakdown region will initiate an avalanche. In each case, this probability is found to be proportional to the excess of the applied voltage over a uniquely definable sustaining voltage V_s, in poor agreement with experiment. The various mechanisms which determine the diode's differential impedance in the conducting state are discussed and approximate expressions for the contributions of each mechanism to the differential impedance are derived. Multilevel pulses, previously interpreted as indicating more than one conducting state for a microplasma, are explained in terms of parallel breakdowns of more than one microplasma.

11,821 ELECTRON-HOLE PLASMA PINCHING IN P-TYPE InSb by B. Ancker-Johnson and R.W. Cohen (RCA Labs.); Bull. Am. Phys. Soc., Ser. II, Vol. 6, p. 310(A), Apr. 24, 1961

Observations of plasma pinching at 77°K in a single crystal of p-type InSb of hole density equal to 2.6×10^{15} cm^{-3} were reported. A microsecond constant-current pulse was used to obtain the necessary electric fields. Contacts to the sample were made in such a way that injection currents were essentially eliminated or, on the other hand, were enhanced. The density of injected holes and electrons did not appreciably affect the current at which pinching began, which was about 2.5 amp (about 1250 amp/cm^2). The field strength at the onset of pinching, however, varied considerably with the quantity of injected holes and electrons, and had a maximum value of about 200 v/cm in the case of minimal injection. Pinch times of tenths of microseconds were measured, in agreement with theory.

Voltage Dependence of Microplasma Density in p-n Si Junctions - See 11,804

11,822 ELECTRONIC PROCESSES IN GOLD-DOPED SILICON TUNNEL DIODES by C.T. Sah (Fairchild Semicon.); Bull. Am. Phys. Soc., Ser. II, Vol. 6, pp. 105-106(A), Mar. 20, 1961

Electronic transitions in the space charge region of Au-doped Si tunnel diodes were discussed. The transitions involve two or more steps in which the intermediate state is one of the two Au levels. Six of the eight possible transition routes have high probabilities. The possible transition routes are: (1) tunneling of a conduction electron horizontally to an acceptor gold level and subsequent emission to the valence band by the neutral gold trap; (2) - (4) similar to (1) involving one of the two gold levels; (5) Hall-Shockley-Read recombination through the gold level; (6), (7) two-step band-to-band tunneling horizontally with one of the two gold levels as intermediate state; (8) a three-step process involving (a) capture of a conduction electron by a neutral gold atom, (b) tunneling of this electron horizontally to an adjacent positively charged gold donor, and (c) emission of the electron by the gold donor to the valence band. Four of these processes have different and observable on-set voltages. Experimentally observed on-set voltages and negative resistance region at around 0.7 v at 4°K corresponding to turning-off of one of the processes (1) - (4) discussed are in good agreement with calculated values.

Secondary Tunneling in GaAs - See 11,948

Tunneling in GaAs and InP - See 11,947

Approximations of the Esaki Integrals - See 11,946

Resistance Measurements on Metal-Thermoelectric Contacts - See 12,007

11,823 ELECTRICAL CHARACTERISTICS OF A REDUCED-AREA, RHODIUM-PLATED, SILICON END CONTACT by M. Green, I.N. Greenberg, J. Banzhaf, A. Sass, H.S. White, and R.V. McKnight (USASRDL); Solid State Electronics, Vol. 3, pp. 1-10, July 1961

The electrical characteristics of a single crystal p-type Si specimen with rhodium-plated end contacts under varying conditions of temperature and current density are discussed. Voltage profile and resistivity measurements made at temperatures of 116° to -196°C are reported. Both injection and extraction appear to be nonlinear functions of the current density at the junction. The contacts (both large and reduced area) become good barriers below -68°C. The rectification characteristic is shown to be highly temperature dependent and conduction mechanisms other than the normal hole conduction in the valence band (or electron conduction in the conduction band) must be considered as a means of low-level conduction through the blocking layer at temperatures in the exhaustion range and below minority-carrier freeze-out.

11,824 OSCILLATIONS IN GERMANIUM WITH AN APPLIED PULSED ELECTRIC FIELD by M. Cardona and W. Ruppel (RCA Ltd.); J. Appl. Phys., Vol. 31, pp. 1826-1827(L), Oct. 1960

Current oscillations observed at room temperature in uniformly doped p-type Ge samples in a pulsed electric field are discussed. The samples had resistivities of 23, 14, and 4.2 ohm-cm. No oscillations were observed in n-type samples or in highly extrinsic p-type samples. A tin soldered contact was made to one end and a rectifying point contact to the other end of the samples, which measured 8, 4, and 2 mm. An experimental arrangement similar to that of Ivanov and Ryvkin was used. The amplitude of the oscillations increased with increasing applied voltage, with a minimum voltage of about 30 v required to produce oscillations. Two oscillation frequencies, ~ 5 kc and ~ 5 Mc, were observed depending on the position of the contact. The oscillations, which were observed only with the rectifying contact biased in the forward direction, were not affected by a longitudinal magnetic field up to 10^4 gauss. The oscillations were either strongly distorted or disappeared under the influence of a transverse magnetic field.

11,825 NUCLEAR QUADRUPOLE COUPLING IN ALKALI IODIDE CRYSTALS by M. Menes and D.I. Bolef (Westinghouse Res. Labs.); J. Phys. Chem. Solids, Vol. 19, pp. 79-86, Apr. 1961

Measurements of the dynamic nuclear quadrupole interaction (first derivative of the quadrupole interaction with respect to strain) for the I^{127} nucleus in crystals of CsI, RbI, KI, and NaI are reported. These measurements were made by observing the resonant absorption of energy from an acoustic wave by the nuclear spins. Longitudinal waves propagating along a cubic axis of the crystal were used. The observed values of the dynamic nuclear quadrupole interaction are: CsI, 1600 Mc; RbI, 615 Mc; KI, 300 Mc; NaI, 660 Mc. These values can be correlated with the chemical shift of the iodine ion in these crystals with the help of a simple model. This model, which is based on work of Townes and Dailey, and Yosida and Moriya, attributes the quadrupole coupling and the chemical shift to the hole left in the outer p shell of the ion. This hole is due to the distortion of the ion (admixture of excited states) by the crystal surroundings. In connection with this work, the chemical shift of LiI^{127} was measured and found to be -3.3×10^{-4}.

Queuing Approximation of Noise in Semiconductors - See 11,980

MAGNETIC PROPERTIES

GENERAL

11,826 MAGNETIC COUPLING IN Pd-DILUTE IRON GROUP ALLOYS by E.O. Wollan (Oak Ridge Natl. Lab.); Phys. Rev., Vol. 122, pp. 1710-1713, June 15, 1961

The magnetic properties of Pd and its alloys with iron group elements are discussed in terms of the splitting of the d orbitals. The paramagnetic properties of pure palladium are accounted for on the basis that the holes in the d shell are associated with the nonoverlapping e orbitals, whereas the ferromagnetic coupling in the face-centered 3d elements and their alloys is associated primarily with holes in the overlapping t orbitals. On this basis and on the basis of a change in the splitting when palladium is alloyed with 3d metals, it is possible to account for the paramagnetic and ferromagnetic properties of the Pd-dilute iron group alloys. Because of the larger amount of available data, attention is given primarily to the Pd-Fe system.

11,827 THEORY OF MAGNETOSTRICTION IN COBALT-MANGANESE FERRITE by J.C. Slonczewski (IBM Res. Ctr.); Phys. Rev., Vol. 122, pp. 1367-1372, June 1, 1961

The magnetostrictive effect of an orbitally degenerate magnetic ion in a cubic ferromagnet is calculated using crystal-field theory. In contrast to previous work, it is not assumed that inter-atomic exchange energy is large compared with spin-orbit energy. The results are applied to the effect of Co in Co-Mn ferrite. It is found that the theory is consistent with experimental results for the magnetostrictive parameters λ_{100} and λ_{111} in the compound $Co_{0.245}Mn_{0.747}Fe_{1.99}O_4$ from 225° - 355°K. By fitting theory to experiment, a trigonal splitting of about 630 cm^{-1} for the ground state of the cobalt ion is inferred. The trigonal splitting has less than half its value in cobalt-iron ferrite.

11,828 MAGNETIC SHORT RANGE ORDER AND SPECIFIC HEAT IN FERROMAGNETS AND ANTIFERROMAGNETS by J.S. Smart (Off. Naval Res. and IBM Res. Ctr.); J. Phys. Chem. Solids, Vol. 20, pp. 41-49, June 1961

The magnetic short-range order parameters and the magnetic specific heat above the transition temperature for both ferromagnets and antiferromagnets are calculated using an extension of the Oguchi method to allow for both the first and second nearest interactions.

11,829 HIGH TEMPERATURE SPIN-SPIN CORRELATION FUNCTIONS IN THE HEISENBERG MODEL by P.J. Wojtowicz (RCA); Bull. Am. Phys. Soc., Ser. II, Vol. 6, p. 55(A), Feb. 1, 1961

The high-temperature behavior of γ_R, the instantaneous spin-spin correlation function, for the Heisenberg model in which the nearest-neighboring pairs of spins possess an interaction of the form $-2J\vec{S}_1 \cdot \vec{S}_2$, was derived. γ_R is defined in terms of the canonical ensemble value $(\vec{S}_0 \cdot \vec{S}_R)_T$ where $\vec{S}_0$ and $\vec{S}_R$ are the spin operators for an atom at the origin and an atom at a general lattice position ψ, respectively. It is demonstrated that γ_R is related to the derivative of the free energy of the spin system with respect to J_R, the strength of a fictitious interaction coupling S_0 to S_R. This result then permits the straightforward evaluation of γ_R in the form of a power series in J/kT, the coefficients of which are computed exactly for arbitrary spins and general lattices by the use of a diagram type of analysis.

11,830 THEORY OF RELAXATION PHENOMENA NEAR THE SECOND-ORDER TRANSITION POINT by T. Tanaka, H.E. Meijer, and J.H. Barry (Catholic U. Am.); Bull. Am. Phys. Soc., Ser. II, Vol. 6, p. 55(A), Feb. 1, 1961

The kinetics of the Ising model were discussed from the point of view of thermodynamics of irreversible processes. An expression for the entropy production when the density, the long-range order, and the short-range order are shifted from their equilibrium values has been obtained from the free energy in Bethe's approximation. By introducing Onsager's reciprocal relation a set of equations for long- and short-range order has been obtained. The solution of the master equations gives two relaxation times which are strongly temperature-dependent functions. One of the relaxation times becomes infinite at the critical temperature but the other remains finite. A long-range constant can be defined even above the critical temperature, since the sound wave will create a certain short-range order which

will in turn create long-range order. An expression for the complex velocity of sound was obtained in terms of these relaxation times.

11,831 COMPUTATION OF ORDER PARAMETERS IN AN ISING LATTICE BY THE MONTE CARLO METHOD by J.R. Ehrman, L.D. Fosdick, and D.C. Handscomb (U. Illinois); U.S. Gov. Res. Rep., Vol. 35, p. 788(A), June 16, 1961 PB 154 103

The long-range and short-range order parameters are computed for the Ising lattice using a Monte Carlo sampling scheme. The square lattice, the simple cubic lattice, and the body-centered cubic lattice are considered. In the three-dimensional calculations both the antiferromagnetic and ferromagnetic cases are considered as well as the coupling to an external magnetic field of various strengths. Agreement is found where the results can be compared with the exact two-dimensional results, and in the three-dimensional case the results agree with those obtained from series approximations in the region where the series approximations are valid. The present method appears to give good results for the short-range order even very close to the critical-temperature, but in this neighborhood the long-range order estimate is crude. The computations were performed on the high-speed computer ILLIAC.

11,832 A NEUTRON DIFFRACTION STUDY OF THE TEMPERATURE VARIATION OF THE SPONTANEOUS SUBLATTICE MAGNETIZATION OF FERRITES AND THE NÉEL THEORY OF FERRIMAGNETISM by T. Riste and L. Tenzer (Brookhaven Natl. Lab.); J. Phys. Chem. Solids, Vol. 19, pp. 117-123, Apr. 1961

Measurements of the temperature variation of the sublattice magnetizations of five different ferrites, using neutron diffraction techniques, are reported. Qualitative agreement with the Néel theory is obtained in all cases in the respect that the magnetization curve of the tetrahedral ions is more convex than the one due to octahedral ions. The data on magnetite are used in a quantitative analysis in terms of molecular field coefficients. It is shown that coefficients determined from conventional magnetic data do not reproduce the sublattice magnetization. This inconsistency is interpreted as an inability of the molecular field equations to take proper account of the magnetic interactions.

11,833 POSSIBILITIES FOR CONTROLLING THE MAGNETIC CHARACTERISTICS OF PERMALLOYS [in German] by F. Pfeifer (Vacuumschmelze); Entwicklungsber. S. and H., Vol. 24, pp. 77-81, June 1961

Variation in the magnetic properties of permalloys obtainable through control of high glowing and tempering procedures is discussed. The factors affected include the temperature coefficient of the initial permeability, the low relative hysteresis coefficient, h/μ_A^2 and the rectangular hysteresis loop. The mechanism of these variations is not clearly understood. Several previous interpretations are compared.

11,834 DISTRIBUTION OF THE MAGNETIZATION IN A FERROMAGNET by M.W. Muller (Varian Assoc.); Phys. Rev., Vol. 122, pp. 1485-1489, June 1, 1961

The distribution of the magnetization is calculated for a thick ferromagnetic slab with easy axis transverse to the plane of the slab in a large applied field in the plane of the slab. The calculation predicts a stable nonuniform distribution which has several features suggestive of the domain pattern to be expected in such a system. In particular, the pattern consists of alternating strips having approximately the periodicity expected from conventional domain theory. Incipient flux closure domains appear if the anisotropy field is smaller than the demagnetizing field.

Susceptibility of Ferrite Material - See 12,015.

11,835 PERMEABILITY AND PERMITTIVITY MEASUREMENT OF GARNET AND FERRITE MATERIALS by G.E. McDuffie, Jr. and J.R. Cunningham, Jr. (Naval Ord. Lab.); U.S. Gov. Res. Rep., Vol. 35, p. 795(A), June 16, 1961 PB 155 386

Measurement techniques used to determine the complex permittivity and complex permeability of toroidal samples of garnet and ferrite materials are discussed. Techniques for permittivity measurements are described for the frequency range 1 kc to 20 Mc. Permeability measurements are divided into two regions: (1) a low frequency range (1 kc to 20 Mc) in which windings are used on the toroidal sample and (2) a high frequency range (20 Mc to 4 kMc) in which the toroid is measured using a thin sample method. The instruments and the sample holders used in the various frequency ranges are described. Equations relating the measured quantities to the complex material constants are derived in detail and errors are considered.

11,836 THE MAGNETIC INVESTIGATION OF Mn^{2+}, Co^{2+}, Ni^{2+}, and Cu^{2+} AMMINE AND ANHYDRATE SALTS AT LOW TEMPERATURES by T. Watanabe (Tokyo Metropolitan U.); J. Phys. Soc. Japan, Vol. 16, pp. 1131-1141, June 1961

Magnetic susceptibility measurements of ammine salts and anhydrate salts of Mn^{2+}, Co^{2+}, Ni^{2+}, and Cu^{2+} ions at liquid helium and liquid hydrogen temperatures are reported. The susceptibility measurements were carried out by the Hartshon bridge method. The salts which were studied are $Mn(NH_3)_6Cl_2$, $Mn(NH_3)_2Cl_2$, $Mn(NH_3)Cl_2$, $MnCl_2$, $Co(NH_3)_6Cl_2$, $Co(NH_3)_2Cl_2$, $Co(NH_3)Cl_2$, $CoCl_2$, $Ni(NH_3)_6 \cdot Cl_2$, $Ni(NH_3)_6(ClO_4)_2$, $Ni(NH_3)_2Cl_2$, $Ni(NH_3)Cl_2$, $NiCl_2$, $Cu(NH_3)_4SO_4 \cdot H_2O$, $Cu(NH_3)_2SO_4$ and $CuSO_4$. The antiferromagnetic or metamagnetic behavior in all other salts except $Mn(NH_3)_6Cl_2$, $Mn(NH_3)_2Cl_2$, $Co(NH_3)_2Cl_2$, $Ni(NH_3)_6Cl_2$, $Ni(NH_3)_6(ClO_4)_2$ and $Cu(NH_3)_2SO_4$ was found in the temperature range from 1.5° to 20.4°K. The magnitude of the Weiss temperature θ is largest for Ni^{2+} and smallest for Mn^{2+} in the coordinated salts of $M(NH_3)_6Cl_2$, $M(NH_3)_2Cl_2$, $M(NH_3)Cl_2$, and MCl_2 (M is one of Mn^{2+}, Co^{2+}, and Ni^{2+} ions). Unexpected results are found in the case of $Ni(NH_3)_6Cl_2$ and $Ni(NH_3)_6(ClO_4)_2$ compared with the results of N.M.R. by Kim and Sugawara.

11,837 NEUTRON DIFFRACTION INVESTIGATIONS OF METALLIC CERIUM AT LOW TEMPERATURES by M.K. Wilkinson, H.R. Child, C.J. McHargue, W.C. Koehler, and E.O. Wollan (Oak Ridge Natl. Lab.); Phys. Rev., Vol. 122, pp. 1409-1413, June 1, 1961

Neutron diffraction experiments performed on metallic cerium at a series of temperatures between room temperature and 4.2°K in an attempt to clarify the anomalous behavior observed in previous specific-heat and magnetic-susceptibility measurements are discussed. Results on three specially prepared samples show that the interesting magnetic behavior can be correlated with the three crystallographic phases present in the samples. There is a change in the electronic configuration of the cerium atoms when the collapsed face-centered cubic phase is formed, and antiferromagnetic ordering occurs in the hexagonal close-packed phase at about 12.5°K.

11,838 THE IDEAL MAGNETIZATION CURVE OF FERRITES WITH DIFFERENT HYSTERESIS LOOP [in German] by M. Kornetzki and E. Roess (Siemens and Halske); Entwicklungsber. S. and H., Vol. 24, pp. 61-64, June 1961

The ideal magnetization curve of various ferrites is derived from the Preisach diagram. The curve begins with a finite slope equal to the initial permeability μ_{ideal} and in ferrites with rectangular, normal, or isoperm hysteresis loop decreases with increasing field strength. In perminvars, the slope first increases and then decreases. Materials with strong hysteresis (rectangular ferrites) have a high ratio of μ_{ideal} to initial permeability while this ratio is low in low hysteresis materials such as isoperms or perminvars.

11,839 ANISOTROPY IN NICKEL-IRON FILMS by D.O. Smith (Lincoln Lab.); U.S. Gov. Res. Rep., Vol. 35, p. 629(A), May 16, 1961 PB 153 563

The magnetic and optical anisotropies of evaporated nickel-iron films deposited at an angle to the substrate normal are discussed. The film anisotropies are sensitive to the rate of deposition and the orientation of the magnetization (M) during deposition. It is postulated that crystalline elongation toward the vapor beam or in the direction of M occurs.

11,840 GALVANOMAGNETIC AND MAGNETIC PROPERTIES OF THIN NICKEL-IRON FILMS by H.J. Juretschke (Polytech. Inst. Brooklyn); U.S. Gov. Res. Rep., Vol. 35, p. 796(A), June 16, 1961 PB 171 569

An investigation of the role of magnetoresistance effects in galvanomagnetic measurements on Ni-Fe films of various compositions is reported. Assuming a reasonable behavior for the magnetization, the following expression has been derived to account for the experimental results for the case of a film in the x-y plane, with current flowing along x: $\epsilon_y/J_x = \Delta\rho m_x + R_1 M m_2$ where ϵ_y = ferromagnetic effect, J_x = current density, ρ = resistivity, M = saturation magnetization, m = the direction of M, and R_1 = the extraordinary Hall constant. With this interpretation, experimental results indicate that the behavior of the magnetization in a truly normal field is unstable with respec to small deviations from the normal; instead of simply lifting out of the film plane, the magnetization also spirals through a large angle. It is thought that galvanomagnetic effects caused by this rotation could persist to very high fields and easily distort the Hall slope far above the knee of the usual Hall curve. The interpretation of the results lead to the conclusion that since the method is so sensitive to the actual behavior of the film, it is more suitable for an investigation of the fine structure of magnetic behavior once the overall properties have been established by some other means.

11,841 DISPLAY OF CRITICAL FIELD CHARACTERISTIC IN THIN MAGNETIC FILMS [in German] by W. Kolb (Siemens and Halske); Elektron. Rechenanl., Vol. 3, pp. 110-113, June 1961

A method of measuring the magnetization properties of thin magnetic films is described. The switching characteristic of such magnetic layers depends on the magnitude and direction of the controlling field; the boundary between the domains of different switching operations is defined by the so-called "critical curve." To obtain a display of this curve two perpendicular alternating fields magnetize the layer and simultaneously control the X- and Y-systems of an oscilloscope. The signals resulting from magnetization changes within the layer appear as light spots on the screen. Some examples are given to demonstrate the application and importance of this procedure.

11,842 PULSE MEASUREMENTS IN THIN MAGNETIC FILMS [in German] by H.J. Harloff and W. Kayser (Siemens and Halske); Elektron. Rechenanl., Vol. 3, pp. 113-118, June 1961

The magnetic phenomena in thin films are discussed. The magnetization of thin magnetic films can be reversed in a few nanoseconds if the reversal takes the form of coherent rotation. The direction and amplitude of the required pulse type fields are governed by a limiting curve which theoretically is an astroid. However experiments using measurements with short pulses show that for first coherent and irreversible rotation of partial areas of the film, this limiting curve lies inside the theoretical astroid, but follows its shape. The completeness of the switching process by coherent rotations is governed by a second limiting curve lying outside the astroid. With increasing duration of the control pulses, incoherent magnetization changes may occur in addition to the coherent changes; the limiting curves for the first irreversible rotations will deviate from the astroid shape with increasing pulse duration, and approach the limiting curve for slow quan-static magnetization changes. The results of measurements of the magnetization properties are presented.

11,843 MAGNETORESISTANCE AND DOMAIN STRUCTURE IN THIN FERROMAGNETIC FILMS by R.L. Coren and H.J. Juretschke (Polytech. Inst. Brooklyn); U.S. Gov. Res. Rep., Vol. 35, p. 621(A), May 16, 1961 PB 148 349

Magnetoresistance measurements used to determine the magnetic domain structure of nickel films are discussed in terms of a new representation in which the resistivity components, parallel and transverse to the current, measured simultaneously as the applied magnetic field varies in magnitude or direction, are regarded as Cartesian coordinates. This representation is independent of the direction of the current relative to any preferred orientations in the film. Marked differences are found between the measured magnetoresistance and the behavior expected of a single domain film. The nature of the differences indicates that these films must at least contain a distribution of uniaxial magnetic regions in the film plane. A particular model having these properties is developed.

11,844 MANGANESE-ZINC FERRITES WITH DIFFERENT HYSTERESIS LOOPS [in German] by M. Kornetzki, E. Moser, and E. Roess (Siemens and Halske); Entwicklungsber. S. and H., Vol. 24, pp. 64-69, June 1961

Investigations which show that all the well-known forms of hysteresis loops become evident if the iron oxide content of Mn-Zn ferrites is changed from about 51 to 58 mole per cent are reported. These forms are the rectangular, normal, isoperm and perminvar loops. The initial permeability has its highest value in the isoperm zone, and the relative hysteresis coefficient h/μ_a decreases in the form order mentioned above. The isoperm ferrites are particularly stable against a temporarily acting magnetic field. In the case that the permeability vs temperature curve of the isoperm ferrites exhibits a secondary maximum, the isoperm effect is particularly distinct near this maximum. With low temperature, e.g. below -80°C, the isoperm loop changes into a loop similar to a rectangle, while at high temperature, e.g. at +100°C, it changes into a normal loop. The isoperm loop comes about spontaneously without any

need for tempering the cores while in the magnetic field; it is caused neither by core anisotropy nor by shearing, but possibly by a large number of Bloch walls.

11,845 MAGNETIC MOMENTS OF YTTRIUM-IRON GARNETS CONTAINING LIGHT RARE EARTH IONS by A. Aharoni and M. Schieber (Weizmann Inst. Sci.); J. Phys. Chem. Solids, Vol. 19, pp. 304-307, May 1961

Measurements of the saturation magnetization between 100° and 700°K in the compounds having a general formula of $Y_{6-x}M_xFe_{10}O_{24}$ (with x = 0-6 for M = Sm, x = 0-4 for M = Nd, x = 0-2 for M = Pr, and x = 0 and 1 for M = La) are reported. No compensation temperature was observed in the temperature interval studied. The low temperature magnetic moments of the Sm and La series are the same as for $Y_6Fe_{10}O_{24}$, i.e., about 10 Bohr magnetons. For the Nd and Pr series, values of 11 for x = 2 Pr to 13 Bohr magnetons for x = 4 Nd were obtained. The Curie temperatures for all these garnets are 550 ± 10°K.

11,846 AN OPTICAL ANALOG TO THE MOTION OF MAGNETICALLY TRAPPED PARTICLES by D. Stern (Maryland U.); U.S. Gov. Res. Rep., Vol. 35, p. 786(A), June 16, 1961 PB 154 243

An analog between the motion of a beam of light confined in a diamond-shaped mirror geometry and the motion of magnetically confined particles is discussed. The long-term behavior of the beam's motion is also investigated, by means of a simplified model. In this model it is shown that the behavior of the solution depends on a certain numerical initial condition and fluctuates according to the term of its continued fraction development. If this is infinite, the fluctuations will go on indefinitely, on a small though not intrinsically limited scale; if on the other hand the numerical value is rational and its expansion finite, the fluctuations will exhibit a recurring pattern which may not be superimposed on a monotonous drift.

Phase Transitions in Ferromagnets - See 11,748

11,847 THEORY OF DOMAIN WALLS IN ORDERED STRUCTURES. Part I. PROPERTIES AT ABSOLUTE ZERO by J.W. Cahn (GE Res. Lab.) and R. Kikuchi (Hughes Res. Lab.); J. Phys. Chem. Solids, Vol. 20, pp. 94-109, June 1961

The energy and entropy of domain walls in ordered structures at 0°K are computed as a function of orientation and composition. Structures in which each atom is at a center of symmetry are treated generally. For these the surface energy, as a function of orientation, has grooved minima for orientations containing bond direction. The surface entropy has cusped minima of zero entropy for the same orientations. Sharp peaks in surface energy as a function of composition occur at the stoichiometric point, and domain walls in nonstoichiometric crystals will have negative surface entropies. Some examples of structures in which some atoms are not at centers of symmetry are given, illustrating the major complications.

11,848 STUDY OF THE LOW-TEMPERATURE TRANSITION IN MAGNETITE AND THE INTERNAL FIELDS ACTING ON IRON NUCLEI IN SOME SPINEL FERRITES, USING MÖSSBAUER ABSORPTION by R. Bauminger, S.G. Cohen, A. Marinov, S. Ofer, and E. Segal (Hebrew U., Jerusalem); Phys. Rev., Vol. 122, pp. 1447-1450, June 1, 1961

A study of the internal fields acting on Fe^{57} nuclei in some spinel ferrites is discussed. Particular reference is made to the low temperature order-disorder transition. Mössbauer absorption techniques are used in the study. For the Fe^{3+} ions at both the octahedral and tetrahedral sites in nickel ferrite ($NiFe_2O_4$) at 300°K, γFe_2O_3 at 85° and 300°K, and magnetite (Fe_3O_4) at 85°K, the effective magnetic field is about 5.1×10^5 oe. In magnetite, the value of H_{eff} in the Fe^{2+} ions is about 4.5×10^5 oe at 85°K. Measurements on Fe_3O_4 at room temperatures provide a microscopic confirmation of Verwey's hypothesis that above the transition temperature of magnetite there is a fast exchange between the ferrous and ferric ions in the octahedral sites.

11,849 HYPERFINE STRUCTURE OF Fe^{57} IN YTTRIUM-IRON GARNET FROM THE MÖSSBAUER EFFECT by C. Alff and G. K. Wertheim (Bell Labs.); Phys. Rev., Vol. 122, pp. 1414-1417, June 1, 1961

The hyperfine structure of Fe^{57} in yttrium-iron garnet [$Y_3Fe_2(FeO_4)_3$], obtained through use of the Mössbauer effect, is discussed. A 0.002-in thick slice of a single crystal of YIG, cut normal to a [110] direction, was used as an absorber of recoil-free gamma rays emitted by a stainless steel source. The iron in YIG is located in two nonequivalent sites, tetrahedral and octahedral, each of which has an axially symmetric electric field gradient. Data were taken with the magnetization aligned in a [111] and in a [100] direction in order to produce the simplest absorption pattern. For each direction of magnetization, the absorption lines of Fe^{57} at both sites have been resolved. The magnetic field at an Fe^{57} nucleus has been found to be 3.9×10^5 oe at a tetrahedral site and 4.7×10^5 oe at an octahedral site when the crystal is at room temperature (~300°K). The quadrupole coupling was found to be 7.5×10^{-8} ev in the tetrahedral site and 9.0×10^{-8} ev in the octahedral site.

11,850 INTERNAL MAGNETIC FIELDS IN MANGANESE - TIN ALLOYS by L. Meyer-Schützmeister, R.S. Preston, and S.S. Hanna (Argonne Natl. Lab.); Phys. Rev., Vol. 122, pp. 1717-1720, June 15, 1961

Measurements of the hyperfine field at the tin sites in two Mn-Sn alloys as a function of temperature to above the Curie points are reported. In addition to the Zeeman splittings, observed and analyzed previously, a possible quadrupole interaction of about 27 Mc is observed in Mn_2Sn. In Mn_4Sn the hyperfine field is small and negative, about -45 koe; in Mn_2Sn it is large and positive, about +200 koe. As in the case of the pure ferromagnetic transition elements, it seems necessary to invoke a positive term associated with conduction-electron polarization and a negative one arising from core polarization to explain these results.

11,851 SPECTROSCOPIC STUDY OF THE YTTERBIUM-IRON EXCHANGE INTERACTION IN YTTERBIUM IRON GARNET by K.A. Wickersheim (Hughes Res. Labs.); Phys. Rev., Vol. 122, pp. 1376-1381, June 1, 1961

Values of the exchange splittings of the Yb ground-state doublet and of an excited state (J = 5/2) doublet, determined from spectroscopic studies of single-crystalline ytterbium-iron garnet, are reported. The splittings, observed at 77°K as a function of the orientation of the magnetization of the crystal, exhibit the functional form of the g tensor of a two-level system. The principal values of the splittings (referred to local x, y, z axes) are, for the ground state doublet, 11.6, 25.7, and 29.9 cm^{-1} and, for the excited state doublet, 15.9, 5.8, and 29.9 cm^{-1}. From the ground state splitting,

using g values for Yb in YGaG, the approximate principal values of the exchange field (assumed to act on the Yb spin magnetic moment only) were found to be 349,000 gauss, 611,000 gauss and 678,000 gauss. The principal values of the effective field (assumed to act on the total magnetic moment) are one-fourth as large as those of the exchange field. On the basis of the ground state exchange splitting, calculations of various macroscopic properties of ytterbium-iron garnet as a function of orientation of magnetization and of temperature have been carried out by others. The calculated properties are generally in good agreement with experiment, but the sharp, low-temperature magnetic anisotropy anomalies which have been observed in Yb-doped YIG are not explained by the spectroscopic data.

11,852 FIELD DEPENDENCE OF THE MAGNETIC SCATTERING IN $CuCr_2O_4$ by R. Nathans (Brookhaven Natl. Lab.), S. J. Pickart (U.S. Naval Ord. Lab. and Brookhaven Natl. Lab.), and A. Miller (RCA Labs.); Bull. Am. Phys. Soc., Ser. II, Vol. 6, p. 54(A), Feb. 1, 1961

Neutron diffraction investigations using an applied magnetic field have substantiated the Yafet-Kittel triangular spin configuration in $CuCr_2O_4$ proposed by Prince. No additional reflections were observed in a pattern taken at 4.2°K beyond those reported at 77°K. The magnetic (111) and (220) reflections of the face-centered spinel cell, in contrast to normal behavior, are found to increase upon application of a magnetic field along the scattering vector, while the (002) reflection remains unchanged. These observations imply that the Cr^{3+} moments must be nearly antiparallel to each other and perpendicular to the net magnetization of the sample, and that they are nearly perpendicular to the tetragonal c axis. The observed increases are in reasonable agreement with a model in which the Cr^{3+} moments lie in (001) sheets with the resultant B site moment pointing either in the [100] or [010] direction. By following the magnetic intensities as a function of temperature the transition point of this spin arrangement is determined to be approximately the same as that found for the spontaneous magnetization. The specimen used in the present study was made up in the form of sintered bars to prevent particle reorientation under the application of the field.

11,853 SPIN WAVE SPECTRUM AT LOW TEMPERATURE by R. Brout and F. Englert (Cornell U.); Bull. Am. Phys. Soc., Ser. II, Vol. 6, p. 55(A), Feb. 1, 1961

Experimental verification of Keffer's and Herring's conclusion that the statement that spin-wave frequencies renormalize with the magnetization is incorrect at low T was presented. For a Heisenberg ferromagnet, at low temperature, the spin-wave frequency at wave number q is given by

$$\omega(q) = 2[v(0) - v(q)]\,R + \frac{4}{N}\sum_{q'}[v(q') - v(q+q')]\,n(q'),$$

where v(q) is the Fourier transform of the exchange interaction and n(q) is the number of spin waves at temperature T. R is the relative magnetization at temperature T. For near-neighbor interactions only, this reduces to Keffer's statement that the spin wave are renormalized with the energy. In general, all that can be said is that R drops out by the sum rule

$$\sum_{q} 2n(q) = N(1-R).$$

11,854 THEORY OF MAGNETOSTATIC MODES IN LONG, AXIALLY MAGNETIZED CYLINDERS by R.I. Joseph (Raytheon and Harvard U.), E. Schloemann (Raytheon); J. Appl. Phys., Vol. 32, pp. 1001-1005, June 1961

The characteristic equation determining the eigenfrequencies of the magnetostatic modes is derived from the equations of motion and the boundary conditions. The solutions may be classified as pertaining to surface and to volume modes. Surface-mode solutions exist only for sufficiently small wave numbers, and their eigenfrequencies are larger than those of volume modes. The eigenfrequencies generally decrease with increasing wave number. Approximate analytic expressions for the dependence of the eigenfrequencies on wave number have been obtained for the regions in which the wavelength is either much smaller or much larger than the cylinder radius. The approximate expressions are compared with numerical results obtained by means of an electronic computer.

11,855 MAGNETOSTATIC MODES OF A FERROMAGNET SLAB by R.W. Damon and J.R. Eshbach (GE Res. Lab.); J. Phys. Chem. Solids, Vol. 19, pp. 308-320, May 1961

The characteristic modes of a thin slab magnetized in its plane are obtained in the magnetostatic limit. It is found that the magnetostatic mode spectrum is bounded by the same frequency limits as for the spheroid. In the slab, however, the mode configuration clearly changes from a volume distribution to a surface wave as the frequency is increased above the extrapolated spin-wave region. In general, the characteristic functions are traveling waves which propagate along the slab transversely to the applied dc magnetic field. The mode distribution in wave-vector space is obtained for both the volume and surface modes, and the dependence of mode density on wavelength is discussed. The mode density variation shows that the volume modes connect smoothly to the spin-wave spectrum of a medium of infinite extent. The surface modes also exist even at very short wavelengths, but become statistically less important as the wavelength decreases.

11,856 MAGNETIC RESONANCE IN CANTED FERRIMAGNETS by P.A. Miles (MIT); Phys. Rev., Vol. 122, pp. 1143-1146, May 15, 1961

The classical theory of the uniform (k = 0) modes of a four-sublattice, planar canted ferrimagnet is developed. Two of these modes should lie in the microwave range for resonable values of applied field, anisotropy, and exchange constants: the normal low-frequency mode familiar in collinear ferrimagnets and the mode excited by longitudinal RF fields at a frequency depending on anisotropy and angle of cant. Observation of this latter mode should allow analysis of ferrimagnetic structures and phase changes.

11,857 DC EFFECTS IN FERROMAGNETIC RESONANCE OF THIN NICKEL FILMS by W.G. Egan and H.J. Juretschke (Polytech. Inst. Brooklyn); U.S. Gov. Res. Rep., Vol. 35, pp. 789-790(A), June 16, 1961 PB 148 757

Observations of ferromagnetic resonance in Ni films thin compared to their skin depth by the appearance of dc electric fields in the film plane are reported. These dc voltages have been attributed primarily to the Hall effect interaction of the microwave electric and magnetic fields by virtue of the precession of the magnetization. The design and execution of a series of experiments to test fully a detailed theory following this assumption proposed by Juretschke are treated. Pulsed

microwave energy at a frequency of 10 kMc and peak powers of 5.6 kw impinges upon a Ni film located transversely in a waveguide in front of a short of adjustable spacing and the observed voltage in the film plane is measured as a function of film location, incident microwave power, direction and magnitude of a static magnetic field. With respect to the latter, the voltage displays a pronounced peaking near the condition for ferromagnetic resonance. As predicted by the theory, the signal is composed of two contributions, one due to the Hall effect, the other due to the ferromagnetic magnetoresistive anisotropy. All detailed features of the theory have been verified in an experimental arrangement in which the greatest care was taken to subject the film to controlled and known local electromagnetic fields, since the microwave boundary conditions at the film can critically influence the observed effects. Four typical films investigated in detail by this method give values of surface resistivity and extraordinary Hall coefficient larger than at dc while the anisotropic resistivity remains unchanged.

11,858 EXTREMELY LOW LOSS ACOUSTIC RESONANCE IN SINGLE-CRYSTAL GARNET SPHERES by R.C. LeCraw, E.G. Spencer, and E.I. Gordon (Bell Labs.); Phys. Rev. Lett., Vol. 6, pp. 620-622(L), June 1, 1961

Observations of acoustic resonance at room temperature in single-crystal spheres of yttrium iron garnet (YIG) are reported. Losses are nearly an order of magnitude lower than for any other known material at the same temperature and frequency. Initial observations were made on a YIG sphere using magnetoacoustic resonance (MAR) techniques. A more desirable direct drive system was developed in which the sphere is driven magnetostrictively at a frequency F/2, exciting a particular acoustic mode at a frequency F. The Q of the driven mode was determined by using the relation $Q = F/\Delta F$. One spheroidal and two radial modes at frequencies 2.10, 3.97, and 9.22 Mc respectively have been investigated. The radial mode at 9.22 Mc has a Q(air) of $2.5 \times (10)^6$ and Q(vac) of $9.5 \times (10)^6$.

11,859 FERROMAGNETISM IN DILUTE SOLUTIONS OF COBALT IN PALLADIUM by R.M. Bozorth, P.A. Wolff, D.D. Davis, V.B. Compton, and J.H. Wernick (Bell Labs.); Phys. Rev., Vol. 122, pp. 1157-1160, May 15, 1961

Measurements of the magnetic properties of solid solutions of Co in Pd which show that ferromagnetism exists in solutions as dilute as 0.1 at. per cent of Co, when the Co atoms are about 10 at. diam apart, are reported. The ferromagnetic Curie point is established in this alloy by three different methods as 7°K. Bohr magneton numbers are determined for the whole series of alloys, and the moment associated with one cobalt atom is found to increase with dilution from 1.7 Bohr units in pure Co to a limit of 9 to 10 units in the greatest dilution. Lattice constants measured at room temperature show the effect of the onset of ferromagnetism at about 10 at. per cent Co. A simple model explains the magnitude and variation of the Co moment.

11,860 MAGNETIC PROPERTIES OF B8 TYPE COMPOUNDS IN MANGANESE-TIN SYSTEM by M. Asanuma (Hokkaido U.); J. Phys. Soc. Japan, Vol. 16, pp. 1265-1266(L), June 1961

The magnetic properties of B8 type compounds in manganese-tin systems are discussed. The homogeneous range of the B8 band structure was found to be sufficiently wide to allow the observation of the magnetic moments of the system, and thus to calculate theoretically the moments of the manganese atoms in each lattice. Specimens of several manganese-tin systems were prepared by melting each component in argon, crushing, baking and quenching. The specimens were examined by the X-ray Debye-Scherrer method to confirm B8 structure. The dependence of saturation magnetization at absolute zero on manganese content was observed and the lattice parameters measured. Saturation magnetization of 0°K decreases as the manganese content increases, and the phase is probably ferrimagnetic. Moments of manganese atoms in A and B sites were calculated and the B8 structure is discussed.

11,861 MICROWAVE PROPERTIES OF POLYCRYSTALLINE HYBRID GARNETS by G.R. Harrison and L.R. Hodges, Jr. (Sperry Microwave); J. Am. Ceram. Soc., Vol. 44, pp. 214-220, May 1961

The microwave properties of polycrystalline solid solutions of YIG with Gd-Fe, Sm-Fe, Y-Al, Y-Ga, and Y-Cr garnets are discussed. Ball-mill mixing techniques were employed in specimen preparation. Line width, saturation magnetization, and effective g-factor measurements were made as a function of composition and temperature for all specimens studied. Curie temperatures were also measured for each specimen. The merits of using these garnet compositions for microwave component applications are increased by the fact that some of their properties may be independently controlled. Data on temperature compensation and high-power effects are presented and the applicability of these materials to microwave solid state devices is discussed.

11,862 POLYCRYSTALLINE FERRIMAGNETIC GARNETS by E.E. Anderson, J.R. Cunningham, Jr. et al. (Naval Ord. Lab.); U.S. Gov. Res. Rep., Vol. 35, p. 796(A), June 16, 1961
PB 155 385

The preparation and properties of polycrystalline samples of YIG and a number of rare earth garnets are discussed. The effect of ionic substitutions on such properties as lattice constants, magnetic moments, dc conductivity, permittivity and permeability are described. The magnetic properties of garnets can be explained by the Néel theory using a 2- or 3-sublattice model. The permeability spectrum shows two absorption regions, one due to domain wall processes in the RF region and the other due to spin resonance in the microwave region. Electrical losses are thought to be due to oxygen defects and the reduction of the ferric ion.

11,863 SEVERAL SOLUBLE ONE-DIMENSIONAL ANTIFERROMAGNETS by E. Lieb, T. Schultz, and D. Mattis (IBM Res. Ctr.); Bull. Am. Phys. Soc., Ser. II, Vol. 6, p. 230(A), Apr. 24, 1961

The ground state properties and thermodynamics of several one-dimensional quantum mechanical antiferromagnetic chains with nearest neighbor interactions were discussed. Two of the models have the Hamiltonians

$$H_1 = S_1 \cdot S_2 + S_2^z S_3^z + S_3 \cdot S_4 + S_4^z S_5^z + \cdots ;$$

and

$$H_2 = \sum_{i=1}^{N} (S_i \cdot S_{i+1} - S_{iz} S_{i+1z}).$$

H_1 and H_2 have no long-range order in the ground state, but some of their anisotropic modifications do have order. Aside from the inherent mathematical interest of such soluble models,

FERRO- AND FERRIMAGNETISM (Cont'd)

he physical properties are also interesting; the thermodynamics and order were found to depend sensitively on the model hosen.

11,864 ANISOTROPY OF THE MAGNETOELECTRIC EFFECT N Cr_2O_3 by V.J. Folen, G.T. Rado, and E.W. Stalder (U. . Naval Res. Lab.); Phys. Rev. Lett., Vol. 6, pp. 607-08(L), June 1, 1961

Measurements of the magnetoelectric effect (resulting from an pplied electric field) in two X-ray-oriented single-crystal isks of Cr_2O_3 are reported. A large anisotropy exists in both he magnitude and temperature dependence of this effect. emperature dependence of the magnetoelectric parameters $\alpha_\perp$ and $\alpha_\parallel$ is plotted. $\alpha_\perp$ is maximum below 100°K and decreases as the temperature increases. $\alpha_\parallel$ is zero at 97°K, ises to a maximum near 240°K, and then decreases. Both arameters are effectively zero at 306°K and remain approximately zero for higher temperatures. A discussion of experimental methods is given.

11,865 MECHANISM OF THE MAGNETOELECTRIC EFFECT N AN ANTIFERROMAGNET by G.T. Rado (U.S. Naval Res. ab.); Phys. Rev. Lett., Vol. 6, pp. 609-610(L), June 1, 1961

. phenomenological theory of the temperature dependence of he magnetoelectric effect is proposed. A fictitious magnetic eld $\vec{h}$ is introduced where $\vec{h}$ is defined by the requirement hat the magnetization $\vec{M}$ is induced by $\vec{h}$ be identical with hat induced by the applied electric field $\vec{E}^a$. Expressions

$$\alpha_\parallel = 4\pi a_\parallel \chi_\parallel \langle S_z \rangle_{av} \text{ and } \alpha_\perp = 4\pi a_\perp \chi_\perp \langle S_z \rangle_{av}$$

re developed. χ is the antiferromagnetic volume susceptibility. $\langle S_z \rangle_{av}$, proportional to the zero-field sublattice magnetization M_o, represents the thermal average of the expectation value of the z component of the ionic spin. $a_\parallel$ and $a_\perp$ re temperature-independent constants of the material. Theoretical predictions of the temperature dependence and of the pproximate magnitude of $a_\parallel$ and $a_\perp$ agree with reported experimental results.

11,866 NUCLEAR ORIENTATION IN ANTIFERROMAGNETIC NGLE CRYSTALS by J.M. Daniels, J.C. Giles, and M.A. . LeBlanc (U. Brit. Columbia); Can. J. Phys., Vol. 39, pp. 3-64, Jan. 1961

Mn^{54} and Co^{60} have been successfully oriented in five antiferromagetic single crystals ($MnCl_2 \cdot 4H_2O$, $MnBr_2 \cdot 4H_2O$, $CoCl_2 \cdot 6H_2O$, $o(NH_4)_2(SO_4)_2 \cdot 6H_2O$, and $MnSiF_6 \cdot 6H_2O$) is discussed. The rientation was detected by the anisotropy of the emitted γ-rays. nly in the case of Co^{60} in $MnBr_2 \cdot 4H_2O$ was no γ-ray anisotpy observed. It is concluded that antiferromagnetism can e used as a means of producing nuclear orientation. Attempts o orient Br^{82} and I^{131} in the manganese halides by superexnange were unsuccessful.

11,867 ANTIFERROMAGNETIC RESONANCE IN FeF_2 AT AR-INFRARED FREQUENCIES by R.C. Ohlmann (U. Califora); Bull. Am. Phys. Soc., Ser. II, Vol. 6, p. 230(A), Apr. 4, 1961

bservations of antiferromagnetic resonance in single crystals FeF_2 between 1.5° and 66°K (T_N = 78.4°K), in the frequency region from 25 cm^{-1} to 100 cm^{-1} were reported. The sonance frequency at $T \approx 0$ is found to be $\tilde{\nu}(0) = 52.7 \pm 0.2$ m^{-1}. From this frequency the uniaxial anisotropy constant at absolute zero, K(0), is inferred to be 1.1×10^8 ergs/cm^3 (40 cm^{-1}/atom). Measurements of the splitting of the line caused by an external magnetic field give $g_\parallel = 2.25 \pm 0.05$. The anisotropy energy in FeF_2, being primarily due to the crystalline field-spin-orbit interaction, may be described by a term $\Sigma_i D_{zi^2}$ in the Hamiltonian. By including this interaction in the molecular-field treatment, it has been found that $D = -9 \pm 2$ cm^{-1}. The temperature dependences of the sublattice magnetization, the anisotropy constant, the resonance frequency, and the line width have been calculated; the last two have been compared with the experimental results and found to be in reasonable agreement. The line widths were found to follow a T^4 law above 15°K.

11,868 ANTIFERROMAGNETIC RESONANCE IN $(Cr_2O_3)_{1-x} \cdot (Al_2O_3)_x$ SINGLE CRYSTALS by S. Foner (Lincoln Lab.); U.S. Gov. Res. Rep., Vol. 35, p. 795(A), June 16, 1961
PB 154 062

Results of pulsed field antiferromagnetic resonance (AFMR) experiments on the mixed crystal system $(Cr_2O_3)_{1-x} \cdot (Al_2O_3)_x$ as a function of temperature and x, (where x = 0.003, 0.006, 0.008, 0.6, 0.1, 0.2, and 0.9) are reported. The temperature dependence of critical field, $(2\lambda°K)^{1/2}$ for pure Cr_2O_3 and for x = 0.1 are compared in detail. The increase of $(2\lambda°K)^{1/2}$ at 4.2°K from about 59 kgauss for Cr_2O_3 to 79 kgauss for x = 0.1 is attributed to a reversal in sign and rapid increase in magnitude of the effective crystalline field contribution to the anisotropy energy as x is increased. AFMR line widths from 800 to 2000 gauss were observed, but for $x \leq 0.2$ the line width was almost independent of temperature for each composition. The decrease of Néel temperature with increase of x is also summarized.

11,869 MAGNETIC PROPERTIES OF INTERMETALLIC COMPOUNDS IN MANGANESE-TIN SYSTEM: $Mn_{3.67}Sn$, $Mn_{1.77}Sn$, AND $MnSN_2$ by K. Yasukōchi, K. Kanematsu (Nihon U.) and T. Ohoyama (Tokyo Metropolitan U.); J. Phys. Soc. Japan, Vol. 16, pp. 1123-1130, June 1961

Measurements of the magnetic properties of $Mn_{3.67}Sn$, $Mn_{1.77}Sn$, and $MnSn_2$ are reported. In $Mn_{3.67}Sn$, an anomalous magnetic phenomenon was found, which may be due to its antiferromagnetism. The Néel temperature T_N, the effective number of Bohr magnetons per Mn n_p, and the asymptotic Curie point θ_a are 365°K, 3.58, and -275°K, respectively. $Mn_{1.77}Sn$ is ferrimagnetic. The estimated saturation magnetization per Mn at 0°K, $n_f \mu_B$, as well as n_p and the Curie temperature T_c, were determined after various heat treatments. When the annealing temperature was lowered, T_c was increased from 226° to 263°K, and n_f was increased from 0.92 to 1.23, while n_p stayed nearly constant at about 3.4. These behaviors are interpreted in terms of the effect of atomic ordering. It was also found that $MnSn_2$ exhibited an antiferromagnetic behavior. T_N, θ_a, and n_p are 324°K, 190°K, and 3.48, respectively.

PARAMAGNETISM

11,870 EFFECTS OF s-d EXCHANGE INTERACTION AND TEMPERATURE-INDEPENDENT PARAMAGNETISM ON SUSCEPTIBILITIES OF NICKEL, PALLADIUM AND PLATINUM by M. Shimizu (Tokyo Metropolitan U.); J. Phys. Soc. Japan, Vol. 16, pp. 1114-1122, June 1961

The well-known discrepancy between the number of the Bohr magneton obtained from the saturation magnetization at 0°K

and that obtained from paramagnetic susceptibilities for Ni is explained by taking into account the s-d exchange interaction, instead of the s-d electron transfer, and the temperature-independent paramagnetism due to the orbital moments of d electrons. The similar discrepancy between the number of magnetic carriers obtained from the paramagnetic susceptibility measurement at lower temperatures and that at higher temperatures for Pd is explained in the same way. The same discussion is applicable to Pt. It is concluded that the temperature-independent paramagnetism is important for an understanding of the temperature variations of susceptibilities of transition metals. The paramagnetic susceptibilities for Ni, Pd, and Pt at higher temperatures are expressed in the form, $C/(T-\theta_p)+\chi_c$. The temperature-independent susceptibility, χ_c, is the sum of the paramagnetic susceptibility of the conduction electron (or s electron) spins and that due to the orbital moment of d electrons.

11,871 MAGNETIC SUSCEPTIBILITY OF CEROUS MAGNESIUM NITRATE by R.P. Hudson and W.R. Hosler (Natl. Bu. Stand.); Phys. Rev., Vol. 122, pp. 1417-1420, June 1, 1961

Measurements of the magnetic susceptibility of cerous magnesium nitrate between 4° and 300°K to provide information on the crystal field parameters as well as the energies of the excited doublets within the J = 5/2 ground multiplet are reported. At low temperatures cerous $MgNO_3$ exhibits extremely anisotropic susceptibility with $g_{||} \approx 0$, a large temperature-independent term $\chi_{\perp}$ and a spin relaxation time dependence $\propto T^{12}$ or higher. The excited doublets, δ_1 and δ_2, are found to be 30 and 200 cm^{-1} in contrast to the previously reported 113 and 150 cm^{-1}. Results are at variance with published data for $\chi_{\perp}$ above 85°K but agree fairly well at low temperatures.

11,872 OBSERVATION OF FORBIDDEN RESONANCES IN OPTICALLY DRIVEN SPIN SYSTEMS by W.E. Bell and A.L. Bloom (Varian Assoc.); Phys. Rev. Lett., Vol. 6, pp. 623-624(L), June 1, 1961

An observation of a forbidden resonance in the $\Delta m = 2$ ($g = 4$, 5.6 Mc sec^{-1} $gauss^{-1}$) transition between the sublevels m = 1 and m = -1 in the 2^3S metastable state of helium is reported. A macroscopic moment precessing at the Larmor frequency was induced in a spin system by the synchronous modulation of an incident beam of optical pumping radiation. The resonance effect may be regarded as an indirect effect employing the coupling of each of the magnetic sublevels to a common optically excited state. It was necessary to assure virtually 100 per cent modulation of the light beam in order to make the signal detectable. This was accomplished by operating in a weak field $H_0 \approx 0.01$ gauss and an observed Larmor frequency $\omega_0/2\pi$ of 24 kc. The g = 4 resonance at 48 kc was observable on an oscilloscope with or without a linear polarizer in the light beam.

11,873 ADIABATIC DEMAGNETIZATION IN A ROTATING REFERENCE SYSTEM by C.P. Slichter and W.C. Holton (U. Illinois); Phys. Rev., Vol. 122, pp. 1701-1708, June 15, 1961

Redfield has proposed that under some circumstances a magnetic resonance should be described by saying the spin system has achieved a temperature in a reference system which rotates at the frequency of the applied alternating field. He based his proposal on experiments in which characteristic times of observation were long compared to the spin-lattice relaxation time. A theory of spin-lattice processes was necessary to analyze the results. A set of experiments to verify this hypothesis is described. The experiments use times short compared to the spin-lattice relaxation, which tests the hypothesis without need for a theory of spin-lattice relaxation. They are shown to be similar to conventional adiabatic demagnetization performed, however, in a rotating reference frame. Redfield's ideas are thereby presented in a particularly simple form. The difference between reversible and irreversible losses in magnetization is illustrated and it is shown, for example, that one can invert the magnetization with respect to the static field by passing through the resonance using alternating fields much less than the linewidth. The studies were made using the Na resonance in NaCl.

11,874 EFFECT OF ILLUMINATION ON THE PARAMAGNETIC RESONANCE OF Ni^{3+} IN RUTILE by H.J. Gerritsen and E. Sabisky (RCA Labs.); Bull. Am. Phys. Soc., Ser. II, Vol. 6, p. 235(A), Apr. 24, 1961

Electron spin resonance observed in Ni doped rutile and ascribed to the lowest doublet of Ni^{3+} (although Ni^{+} cannot be completely ruled out) was discussed. There are four ions in the unit cell in contrast to many other ions studied in rutile. These ions are magnetically identical along the c-axis having a g value of 2.085. In the plane perpendicular to the c-axis, the axes of the four g tensors make angles of ±35° with the crystal a-axis, having values of 2.084 and 2.254. This center is observed at room temperature and below, and ascribed to Ni^{3+} at a Ti^{4+} site with one of the neighboring oxygen ions as O^-. If the sample is illuminated, a broad additional spectrum appears at room temperature. It narrows below 200°K, and its intensity can be made comparable to the above mentioned spectrum. The symmetry is, however, that of a Ti^{4+} site with the customary two nonequivalent ions in the unit cell. It is ascribed to the recapturing of an electron by the O^- ion. Illumination at liquid helium temperature shows two more rather intense Ni spectra which can be ascribed speculatively to electron losses in other neighboring oxygen ions.

11,875 SPLITTING OF THE EMISSION LINES OF RUBY BY AN EXTERNAL ELECTRIC FIELD by W. Kaiser, S. Sugano, and D.L. Wood (Bell Labs.); Phys. Rev. Lett., Vol. 6, pp. 605-607(L), June 1, 1961

Experimental data and a proposed theory to explain pseudo-Stark splitting of the emission lines of ruby by an external electric field are given. The splitting of $\Delta\nu$ is directly proportional to the electric field. Both doublet lines R_1 = 14, 421 cm^{-1} and R_2 = 14, 450 cm^{-1} are split by the same amount. The frequency shift is so large that the two center lines pass the midpoint between the two original R_1 components at a field of about 65 kv/cm and cross over at still higher fields. The apparent splittings are due to opposite Stark shifts of the energy levels of chromium ions at different lattice sites. Application of an ac electric field should allow frequency modulation of the output of a ruby maser.

11,876 PHONON MASERS AND THE PHONON BOTTLENECK by C. Kittel (U. California); Phys. Rev. Lett., Vol. 6, p. 449(L), May 1, 1961

The conditions for a phonon bottleneck in which the lattice phonons cannot carry off to the heat bath all the power delivered to them by a paramagnetic system are discussed. The buildup of stimulated phonon emission and the basis for phonon maser action with paramagnetic ions radiation phonons occur

when the initial rate at which the spin system transfers energy to an isolated phonon mode exceeds the phonon energy decay rate. It is estimated that the condition could be fulfilled if the excess per unit volume of paramagnetic ions in their upper state were to exceed 0.5×10^{18} cm^{-3}; hence, phonon maser action appears feasible.

11,877 CONTRIBUTION TO THE THEORY OF SPIN-LATTICE RELAXATION OF NUCLEAR SPINS IN IONIC CRYSTALS by B.I. Kochelaev (Kazan State U.); Soviet Phys.-JETP, Vol. 10, pp. 171-175, Jan. 1960

Relaxation of nuclear spins in ionic crystals at room temperature is examined theoretically, taking into account optical vibrations of the crystal lattice. Numerical calculations are made for NaCl type lattices; agreement with experiment is satisfactory.

11,878 LINEWIDTH BROADENING OF THE F^{19} NUCLEAR RESONANCE IN MnF_2 NEAR THE NÉEL TEMPERATURE by P. Heller and G.B. Benedek (Harvard U.); Bull. Am. Phys. Soc., Ser. II, Vol. 6, pp. 233-234(A), Apr. 24, 1961

Studies on the linewidth of the F^{19} resonance in MnF_2 as a function of temperature near the Néel temperature T_N (~68°K), using a system capable of temperature stabilization to within one millidegree for long periods of time, were discussed. In the paramagnetic state the line broadens markedly as T_N is approached. At a given temperature, this broadening depends strongly on the direction of the applied field H_0 with respect to the crystal axes, being more marked with H_0 along the c-axis than with H_0 along the a-axis. T_N was taken as the temperature at which the line broadens to the point of disappearance with H_0 along the a-axis. This point can be determined to within about 1 millidegree. In the temperature range $0.090°K \leq T - T_N \leq 4°K$, the linewidths vs temperature can be represented by the empirical formula $\delta H(T) = (\delta H_0) + k/(T - T_N)$, where $k = 2.2$ gauss °K, $(\delta H)_0 = 24.5$ gauss for H_0 along the a-axis and $k = 6.5$ gauss °K, $(\delta H)_0 = 24$ gauss for H_0 along the c-axis. With H_0 along a, observations have also been made at temperatures as close as 88 millidegrees above T_N. Preliminary results indicate that the line shape changes in this region.

11,879 NUCLEAR RESONANCES IN TaC AND NbC by L.H. Bennett (Natl. Bu. Stand.); Bull. Am. Phys. Soc., Ser. II, Vol. 6, p. 233(A), Apr. 24, 1961

Measurements of the nuclear magnetic resonances of Ta^{181} in TaC powder and Nb^{93} in NbC powder at room temperature were discussed. Each show a small (about 0.1 per cent) diamagnetic shift. Since both TaC and NbC are metallic conductors at room temperature and NbC is considered a superconductor at helium temperatures, these negative "Knight" shifts are unusual. Diamagnetic shifts previously observed in alloys (or intermetallic compounds) containing transition metals were of the nontransition element only. The transition element, vanadium, displayed paramagnetic shifts of the same order of magnitude as the Knight shift in metallic vanadium. The resonance results on the carbides were discussed with relation to other physical properties of these materials, and the problem of sample characterization was considered.

11,880 KNIGHT SHIFTS AND QUADRUPOLE EFFECTS IN Al ALLOYS by M.B. Webb (GE Res. Labs.); J. Phys. Chem. Solids, Vol. 20, pp. 127-133, June 1961

Observations of the Al^{27} nuclear resonance in AlZn and AlMg as a function of composition, temperature, and applied magnetic field are reported. At temperatures where the dipolar width is motionally narrowed but where the quadrupole splitting of the satellite lines is not, the second order quadrupole shift of the central transition is readily measureable. It is then possible to measure directly the average electric field gradient at the Al nuclei and the average Al Knight shift in the alloy. The measured gradients are essentially the same in AlMg and AlZn alloys, consistent with the suggestion that the gradients arise from the electronic charge distribution about the solute and not from strain effects. The average gradients are of the order of 1×10^{23} cm^{-3}. The Al Knight shift in the alloys is equal to that in pure Al to within the experimental uncertainty. The results are compared with the previous experiments of Rowland and the theory of Blandin and Friedel.

11,881 MECHANISM OF DOUBLE RESONANCE IN SOLIDS by J. Lambe, N. Laurance, E.C. McIrvine, and R.W. Terhune (Ford); Phys. Rev., Vol. 122, pp. 1161-1170, May 15, 1961

A study of electron-nuclear double resonance (ENDOR) in ruby and other solids which demonstrates the existence of the "distant-ENDOR" effect is described. This effect involves a change in the electron paramagnetic resonance (EPR) signal caused by the depolarization of "distant" nuclei (nuclei having negligible hyperfine interaction with the paramagnetic centers). In order to obtain interpretable data on the mechanism, most of the experiments were performed without modulation, observing not the derivatives but the functions χ' and χ'' themselves, the dispersive and absorptive parts of the spin susceptibility. The former shows a large decrease upon application of RF power at a nuclear transition frequency; the latter shows a moderate increase. Both the distant ENDOR (Al^{27} nuclear Zeeman frequencies) and local ENDOR (Cr^{53} hyperfine frequencies) affect the EPR with a response time comparable to the spin-lattice relaxation time of the distant aluminum nuclei. Nuclear-nuclear double resonance experiments show that applied RF corresponding to Cr^{53} nuclear transitions depolarizes Al^{27} nuclei. Both of these observations are consistent with a mechanism involving dynamic nuclear polarization. A theoretical analysis of this mechanism, based on forbidden transitions involving distant nuclei, gives good agreement with observed nuclear polarizations and with the observed behavior of χ', but predicts small increases in χ''. The increased absorption signal can be explained by enhanced spectral spin diffusion or by a spin packet considerably wider than assumed. Distant ENDOR is expected to occur quite generally.

11,882 ENDOR IN DILUTE RUBY by J. Lambe, N. Laurance, and E.C. McIrvine (Ford); Bull. Am. Phys. Soc., Ser. II, Vol. 6, pp. 297-298(A), Apr. 24, 1961

ENDOR experiments carried out in dilute ruby (0.01 per cent Cr) at 4.2°K were discussed. In this material ENDOR lines which can be assigned to Al^{27} nuclei near the Cr^{3+} sites are observed. The mechanism whereby these nuclei are observed is probably the "packet shifting" ENDOR described by Feher as opposed to the depolarization ENDOR which also occurs in ruby. The speed of response of the ENDOR effects is used in distinguishing these different mechanisms. The "packet shifting" ENDOR should have a response time corresponding to the electron T_1, the depolarization effect corresponding to the nuclear T_1. The ENDOR measurements were made while transitions

corresponding to

$$S_z + \frac{1}{2} \rightarrow + \frac{3}{2} \text{ or } \frac{1}{2} \rightarrow + \frac{1}{2}$$

were saturated. A given transition yields of the order of 100 ENDOR lines. The spectrum is not yet completely analyzed but some features are clear. A major point is the large variation in nuclear quadrupole splitting of the Al^{27} nuclei, which vary from 260 to 500 kc compared with the normal splitting of 360 kc. This presumably is a measure of the distortion in the crystalline electric field near the Cr^{3+}.

11,883 NUCLEAR DEPOLARIZATION AS AN ENDOR MECHANISM by E.C. McIrvine, J. Lambe, N. Laurance and R.W. Terhune (Ford); Bull. Am. Phys. Soc., Ser. II, Vol. 6, p. 297(A), Apr. 24, 1961

A mechanism of electron-nuclear double resonance (ENDOR) wherein an EPR signal serves to detect the removal of a dynamic nuclear polarization is described. Since the application of auxiliary RF power at some transition frequency Δ of the nuclear system removes this polarization, nuclear transition frequencies may be sensitively detected. The mechanism applies in the case of an EPR line inhomogeneously broadened by the presence of a magnetic nuclear species. The application of microwave power at a frequency ω on one side of such a line not only saturates the allowed electron spin transitions in the spin packet at ω but also causes forbidden transitions flipping both electron and nuclear spins. The saturation of the electron spin packets at $\omega - \Delta$ and $\omega + \Delta$ is limited by the principle of detailed balance for the nuclear spin population, which sets up a steady state dynamic nuclear polarization. The application of RF at the nuclear transition frequency Δ removes this nuclear polarization and changes the EPR signal. This mechanism is consistent with experimental results on "distant" Al^{27} nuclei in ruby (nuclei having negligible hyperfine interaction with the chromium ion).

11,884 OPTICAL SATURATION OF F-CENTER SPIN RESONANCE by B.R. McAvoy, D.W. Feldman, J.G. Castle, Jr. and R.W. Warren (Westinghouse Res. Labs.); Phys. Rev. Lett., Vol. 6, pp. 618-620(L), June 1, 1961

The influence of external light on the spin resonance of F-centers of KCl is discussed. Results of experiments at 9.0 kMc on very pure samples of KCl, in which both the steady state population difference and the spin relaxation time were measured during exposure to light are reported. Irradiation by light in the F-band was found to influence the populations of the ground-state sublevels; lattice heating was found to be negligible. The model for optical saturation in which the excitation of isolated F-centers occurs to these bound excited states is confirmed. There is essentially no preferrential pumping. The data also allows a comparison of absolute rates.

11,885 ELECTRON SPIN RESONANCE OF MANGANESE IN $MgCl_2$ by K. Fukuda, H. Matsumoto, T. Takagi and Y. Uchida (Kyoto U.); J. Phys. Soc. Japan, Vol. 16, p. 1256(L), June 1961

Observations of electron spin resonance in $MgCl_2$ are discussed. Single crystal $MgCl_2$-Mn was prepared by heating and slow cooling in an evacuated quartz tube. The electron spin resonance of the Mn was measured at room temperature using 1.2 cm wavelength microwaves by rotating the static magnetic field around the c-axis in the plane perpendicular to it. The spectra consist of a broad line of about 450 oe peak-to-peak width and many sharp lines of about 40 oe peak-to-peak width. The sharp lines can be attributed to the hyperfine structure of the Mn^{++} ion. It seems plausible that the Mn^{++} ions occupy the regular sites in the host crystal, however, further experiment is necessary to determine the relationship between the broad line and the hyperfine lines.

11,886 PARAMAGNETIC RESONANCE OF Cr^{3+} IN YTTRIUM OXIDE by J. W. Carson, D. P. Devor and R. H. Hoskins (Hughes Res. Labs.); Phys. Rev., Vol. 122, pp. 1141-1143, May 15, 1961

Observations of the paramagnetic resonance spectrum of Cr^{3+} in single-crystal yttrium oxide at microwave frequencies from 9 to 71 kMc at temperatures from 4.2° to 300°K are reported. The spectrum is described in terms of the spin Hamiltonian $\mathcal{H} = g\beta H \cdot S + D[S_z^2 - S(S+1)/3]$, where $g = 1.97 \pm 0.01$, $S = 3/2$ and $2D = 72.9 \pm 0.2$ kMc at 300°K, and 72.7 ± 0.2 kMc at 77° and 4.2°K.

DIAMAGNETISM

11,887 OBSERVATIONS OF DE HAAS-VAN ALPHEN OSCILLATIONS IN P-TYPE PbTe by P.J. Stiles, E. Burstein and D. N. Langenberg (U. Pennsylvania); Phys. Rev. Lett., Vol. 6, pp. 667-669(L), June 15, 1961

Results of a study of magnetic susceptibility oscillations in p-type PbTe by means of pulsed magnetic field techniques are reported. In each of the four cylindrical samples studied, more than 30 oscillations were observed. Three boule-adjacent samples yielded a hole density of $3 \times 10^{18}/cm^3$ by Hall effect methods, the fourth sample having a hole density of $1 \times 10^{18}/cm^3$. The data indicate a band maximum at $\vec{k} = 0$ and band maxima at the centers of the {111} faces of the Brillouin zone. Assuming parabolic bands, the Fermi energy surfaces of the {111} zone faces are ellipsoids of revolution. Estimates of transverse effective mass of the ellipsoids, effective mass of the central section and electron energy at the $\vec{k} = 0$ band edge are given. The signals observed are 10 to 100 times smaller than typical signals observed in experiments on metals. Experimental de Haas-van Alphen periods are listed.

11,888 DE HAAS-VAN ALPHEN EFFECT IN POTASSIUM by A.C. Thorsen and T.G. Berlincourt (NA Aviation); Phys. Rev. Lett., Vol. 6, pp. 617-618(L), June 1, 1961

De Haas-van Alphen oscillations in a single crystal of potassium in pulsed magnetic fields of up to 160 kilogauss are discussed and scope waveforms are presented. Measurements yield a period of $5.75 \times 10^{-9} \pm 1\%$ gauss^{-1}, indicating a cross-sectional area of the Fermi surface of 1.66×10^{16} cm^{-2}, in good agreement with that predicted from the free-election model.

OPTICAL PROPERTIES

ABSORPTION (TRANSMISSION)

11,889 OBSERVATION OF QUANTUM EFFECTS IN GERMANIUM AND SILICON AT MILLIMETER WAVELENGTHS by J. J. Stickler, C. Rauch, H.J. Zeiger and G.S. Heller (Lincoln Lab.); Bull. Am. Phys. Soc., Ser. II, Vol. 6, p. 115(A), Mar. 20, 1961

Observations of quantum effects in p-type Ge and Si at 4 and 2 mm using cavity spectrometers with light modulation were discussed. The observations were made at 1.2°K and above as a function of crystal orientation. Measurements on Ge at 2 mm and 1.2°K were in essential agreement with the 1.25 cm wavelength data of Fletcher, Yager and Merritt. Additional lines not reported by Fletcher were observed in the vicinity of the classical heavy hole in the [100] direction and in the vicinity of the classical light hole in all directions. In the 2 mm data the classical heavy and light hole resonances occurred only above 4.3°K. For the case of Si observations were made at 2 mm and from 1.2° to 4.3°K. Experimental data were presented along with preliminary analysis of the results using Luttinger's theory.

11,890 X-RAY INDUCED CONVERSION IN THE ABSORPTION BANDS OF ADDITIVELY COLORED KCl by G. Baldini, L. Dalla Croce and R. Fieschi (Inst. Sci. Fis. U.); Nuovo Cim., Vol. 20, pp. 806-811(L), May 16, 1961

Observations of the direct optical effects of X-rays on vacancy clusters which bind one (or more) electrons, namely the changes induced by the ionizing radiation on the complex absorption centers (M, R and N) and Z centers, in additively colored CKI are reported. The spectrum of the samples showed a strong F band but very weak M and R bands. Successive illumination with F-light at room temperature caused the well known conversion of F centers into M, R and N centers. The curves for the maximum absorption coefficients of the various bands as a function of X-ray exposure time are presented. The observed behavior of the complex centers has been explained as due to thermal spikes or as a consequence of hole trapping by the electronic center, followed by dissociation of the vacancy aggregate. By comparison with the effect of a purely thermal bleaching above 200°C followed by quenching, it appears that the first mechanism does not play the major role. The absorption spectra of a sample containing F, Z and Z_2 centers before and after the X-ray irradiation are also discussed. The rate of $Z_1 \rightarrow F$ conversion is shown to be lower than that of $Z_2 \rightarrow F$ conversion.

11,891 THE OPTICAL ABSORPTION EDGE OF VERY IMPURE GERMANIUM by J.I. Pankove (RCA Labs.); Bull. Am. Phys. Soc., Ser. II, Vol. 6, pp. 303-304(A), Apr. 24, 1961

Measurements on the absorption of arsenic-doped Ge (in the range 5×10^{18} to 6.2×10^{19} cm^{-3}), made at room temperature with an accuracy of about 1 cm^{-1} and a resolution of 0.0015 ev, were discussed. The free carrier absorption, extrapolated to the range of across-the-gap transitions, was subtracted from the measured absorption coefficient. An approximate solution of the energy dependence of the absorption coefficient for the case of a degenerate parabolic band allows a Macfarlane-Roberts type of interpretation. The most striking effect is a shift of the whole conduction band by several hundredths of an ev closer to the edge of the valence band. The filling of the band by the Fermi sea is also evident.

11,892 ABSORPTION EDGE IN DEGENERATE P-TYPE GaAs by I. Kudman and T. Seidel (RCA); Bull. Am. Phys. Soc., Ser. II, Vol. 6, p. 312(A), Apr. 24, 1961

Measurements on infrared absorption at room temperature for p-type degenerate GaAs for various hole concentrations were discussed. A Burnstein-like shift observed for samples doped above $10^{19}/cm^3$ is associated with a decrease in the valence band electron population. The data are also consistent with a large valence band effective mass and direct transitions where the matrix element does not depend strongly upon energy. Inflections are also detected in the absorption data. Resistivity vs carrier concentration (Hall effect) on similar material was presented. The mobility dependence on hole concentration is less strong than that observed for Ge for comparable doping.

11,893 EFFECT OF PRESSURE ON THE ABSORPTION EDGES OF SOME III-V, II-VI, and I-VII COMPOUNDS by A. L. Edwards and H.G. Drickamer (U. Illinois); Phys. Rev., Vol. 122, pp. 1149-1157, May 15, 1961

Measurements of the effect of pressure to 160 kilobars on the absorption edges of the III-V compounds AlSb, GaSb, InP and InAs, the II-VI compounds CdS, CdSe and CdTe, and the I-VII compounds CuCl, CuBr and CuI are reported. For the II-VI and I-VII compounds, ionic and other effects are found to be important. A number of new phase transitions were noted at high pressure. The T-P curves of some of these transitions were established for CuCl and CuBr.

11,894 INFRARED ABSORPTION BEYOND THE FUNDAMENTAL ABSORPTION EDGE IN PbS AND PbTe by H.R. Riedl (U.S. Naval Ord. Labs.); Bull. Am. Phys. Soc., Ser. II, Vol. 6, p. 312(A), Apr. 24, 1961

Infrared absorption measurements made on PbS and PbTe in the 3 to 30 μ wavelength region at temperatures ranging from 18° to 300°K were discussed. The absorption coefficient due to free carriers is found to be proportional to λ^n, where λ is the wavelength and n varies from 2.0 to 2.7. For example, in p-type PbS with a room temperature carrier concentration of 2.6×10^{18} holes/cm^3, the abosrption coefficient at 300°K, for λ between 4 and 9 μ, is $(1.29 \pm 0.13)^{2.45 \pm 0.05}$ cm^{-1}. In p-type PbTe, additional absorption varying more slowly with wavelength is also observed. This additional contribution is clearly seen from the fundamental absorption edge to about 15 μ at 300°K, and from the edge to about 11 μ at 196°K, and is stronger at 300°K.

11,895 SPECTROPHOTOMETRIC STUDIES ON THE CONTINUOUS SPECTRA OF Cu_2 AT VARIOUS TEMPERATURES [in French] by J.B. Grun, M. Sieskind and S. Nikitine (Inst. Phys., Strasbourg, France); J. Phys. Chem. Solids, Vol. 19, pp. 189-197, May 1961

Measurements of the absorption of samples of different thicknesses (from 10 to 180 μ) of synthetic Cu_2O at different temperatures (293°, 249°, 169°, 104°, 77°, 20° and 4°K) are reported. Different parts of the spectrum where the absorption is continuous are described. The red continuum is situated on the low energy side of the yellow series, the yellow continuum on the high energy side. Both are explained by Elliott's theory of indirect and forbidden transitions. The red continuum is thought to be an indirect transition with phonon creation and annihilation to the first exciton state n = 1. At high temperatures, the yellow series disappears and is replaced by a continuum which is characteristic for a forbidden band-to-band transition. The "yellow" continuum corresponds to the continuous absorption on the high energy side of the series limit.

11,896 THE INFRARED ABSORPTION AND THE ENERGY-BAND STRUCTURE OF CUPROUS OXIDE by M.P. Lisitsa and G.A. Kholodar' (T.G. Shevchenko State U., Kiev); Soviet Phys.-Solid State, Vol. 2, pp. 1897-1903, Mar. 1961

Infrared transmission (in the region 0.6 - 24 μ) of polycrystalline Cu_2O samples of various thicknesses is investigated. Beyond

the fundamental absorption edge, a background was found due to excess oxygen. Apart from the known absorption maxima, several new ones were found whose origin was not clear. Studies of the effect of temperature on individual bands and an attempt to detect polaron absorption are described. It was found that the 12.6 μ band was of electronic origin.

11,897 INFRARED ABSORPTION IN MAGNESIUM SILICIDE AND MAGNESIUM GERMANIDE by P. Koenig, D.W. Lynch and G.C. Danielson (Iowa State U.); J. Phys. Chem. Solids, Vol. 20, pp. 122-126, June 1961

Measurements of infrared absorption spectra of several n-type Mg_2Si and Mg_2Ge single crystals in the wavelength regions from 1 - 13 μ and 1 - 7 μ, respectively, over the temperature range from 85° - 370°K are reported. Free carrier absorption occurred in Mg_2Si at the longer wavelengths. The absorption edges appear to be due to indirect transitions and the shift of the optical energy gap with temperature is estimated to be -5×10^{-4} ev/°K for Mg_2Si and -6.5×10^{-4} ev/°K for Mg_2Ge. No values for the gaps were determined from the present data but they can be seen to be approximately equal to those determined by electrical measurements. An absorption peak observed at 0.40 ev in n-type Mg_2Si is discussed.

RADIATION

11,898 INFRARED SPECTRAL EMISSIVITY OF OPTICAL MATERIALS by D.L. Stierwalt (Naval Ord. Lab.); U.S. Gov. Res. Rep., Vol. 35, p. 792(A), June 16, 1961 PB 171 254

Measurements on the spectral emissivity of several optical materials in the 2 to 15 μ region of the infrared spectrum at temperatures of 40° to 180°C are discussed. The emission from each sample was compared with that from a black body by means of a modified Beckman IR-3 spectrophotometer. Spectral emissivity curves are presented for Ge, Si, CdS, KRS-5, glass and quartz. From these data the absorption coefficient for Ge and CdS was calculated. The results indicate that this method is an excellent one for measuring low values of the absorption coefficient.

11,899 CONSTRUCTION OF AN INFRARED SOURCE OF HIGH LUMINANCE (Lab. d'Infra Rouge Tech. et Appl., Gif-Sur-Yvette); U.S. Gov. Res. Rep., Vol. 35, p. 792(A), June 16, 1961 PB 153 467

A spectroscopic study of CdS, either pure or activated with Ag or In, and HgS is reported. Besides the red radiation already known from ultraviolet irradiation experiments, a green light of unknown origin was observed, its wavelength being close to that characteristic of the absorption limit of CdS. This radiation has no appreciable inertia and is therefore of interest for optical telecommunication. It appears to compete with the red of infrared radiation which we know, and it probably plays a part in the destruction of powders by bombardment. An investigation of this phenomenon is therefore important, especially since an effect of similar origin is observed in the case of HgS. The first results of this research are given, together with some theoretical observations aimed at its interpretation.

11,900 CORRELATION OF ZnTe AND OTHER II-VI COMPOUND BAND EDGE EMISSION SPECTRA by R.E. Halsted and M. Aven (GE Res. Labs.); Bull. Am. Phys. Soc., Ser. II, Vol. 6, p. 312(A), Apr. 24, 1961

Measurements at 20°K on the five sets of emission lines of ZnTe, showing an 0.0259 ± 0.0005 ev phonon structure, were reported. The highest energy lines of four sets occur at 2.375, 2.329, 2.323 and 2.237 ev. An emission band was observed at 1.87 ev with superimposed phonon structure. Corresponding spectra for CdS, ZnSe and CdTe are substantially consistent with prior work and permit informative comparisons. Reststrahlen and dielectric constant data in these compounds correlate with longitudinal optical phonons. Such structure must generally characterize phonon emission processes within 0.3 ev (at 20°K) of band gap energy in II-VI compounds. The width, relative intensity and number of satellite lines in a set increase for the more tightly bound recombination centers which are more strongly coupled to the lattice. However, variations observed in this trend help to characterize the recombination process involved. In ZnSe reversible changes in the edge emission spectra were produced by variation of stoichiometry. Several types of recombination mechanisms are necessary to acount for the diversity of spectra and their dependence on bulk chemical properties.

LUMINESCENCE

11,901 SOME SPECIAL CASES OF LUMINESCENCE KINETICS by V.V. Antonov-Romanovskii (Acad. Sci., USSR); Optics and Spectrosc., Vol. 10, pp. 107-110, Feb. 1961

Decay in the presence of two kinds of traps having slightly different depths is discussed. It is shown that the quadratic dependence of the steady-state photoconductivity on the intensity of the exciting light can be explained within the framework of the conventional zone model of a phosphor.

11,902 RECOMBINATION COEFFICIENTS OF CaO LUMOPHORS FOR NITROGEN ATOMS by K.M. Sancier, J.L. Hatchett, W.J. Fredericks and H. Wise (Stanford Res. Inst.); Bull. Am. Phys. Soc., Ser. II, Vol. 6, p. 111(A), Mar. 20, 1961

Measurements on the quantity of heat released and the intensity of luminescence produced in the heterogeneous recombination of nitrogen atoms on the surface of lumophors such as CaO were reported. The quantity and intensity were measured as a function of distance from the atom source (an electrodeless RF discharge in dry nitrogen). From these measurements the recombination coefficients for heat and light production (γ^H, γ^L) have been evaluated. For pure CaO the values of γ^H and γ^L are found to be different. Activation of CaO with Mn produced a second luminescence band at longer wavelength with $\gamma_{CaO:Mn}{}^L$ different from $\gamma_{CaO}{}^L$. These results suggest different mechanisms of recombination-energy transfer and conversion in the production of luminescence and heat.

11,903 DOSIMETRY BY LUMINESCENCE DEGRADATION IN ORGANICS by F.H. Attix (Naval Res. Lab.); U.S. Gov. Res. Rep., Vol. 35, p. 617(A), May 16, 1961 PB 171 491

An investigation of the phenomenon of photoluminescence degradation in organic materials due to damage by ionizing radiations is reported. A survey of previous studies of this effect is presented. The present work stresses reduction to a practical dosimetry system for the 5×10^5 to 5×10^9 rad absorbed dose range. It is demonstrated that pressed wafers of anthracene and of p-quaterphenyl can be employed together to cover the required

pse range. Ultraviolet light (3650 A) is used to excite the hotoluminescence, which is observed in a narrow band at 420 A. Some recovery of photoluminescence with time after -ray irradiations is observed, and heat treatment is proposed s a method of reducing this effect. Degradation of lumines- ence in biphenyl, p-terphenyl, fluorene, naphthalene and etracene is also discussed.

1,904 ELECTROLUMINESCENCE OF THIN ZnS FILMS by .A. Thornton (Westinghouse); Bull. Am. Phys. Soc., Ser. , Vol. 6, p. 266(A), Apr. 24, 1961

he ac electroluminescence of thin ZnS:Cu, Cl films was com- ared with that of powder phosphors. The major difference was ound to be that strong asymmetry in the films causes light emis- on only during the half-cycle of the applied voltage when the ansparent tin oxide electrode upon which the film is formed is egative. The other (aluminum) electrode plays no part since n intermediate insulating layer has no effect. The resistive urrent component in the films is, however, symmetrical with oltage polarity, as are both light and current in powder phos- nors; this implies that the electrodes are never involved and hat current and light emission are controlled by internal junc- ons in both phosphor films and powders. Direct current, as ell as instantaneous ac current (resistive), in these films is roportional to $[\exp(V/V') - 1]$, where V' is a constant. If ther voltage half-cycle is clipped (or eliminated) by a recti- er, the light emission is reduced (or eliminated). Direct oltage bias, added to the alternating voltage, has the same ffect although in this case the rms voltage is constant; the fect of the sign of the dc bias voltage indicates that the ion- ation process occurs during one half-cycle (with no light mission), and that the resulting light emission occurs on the llowing half-cycle.

,905 MATERIAL AND ENCLOSURE EFFECTS ON THE HRESHOLD FOR PULSATIONS IN INDUCED FLUORESCENCE R.W. Hellwarth (Hughes Res. Labs.); Bull. Am. Phys. Soc., r. II, Vol. 6, p. 266(A), Apr. 24, 1961

he nature of the pulsations in the induced fluorescence from a hree-level" crystal excited between two parallel reflecting ates was estimated for the case where interference effects ay be neglected. In this same case, the threshold level of citing (pump) radiation, measured by the pump transition rate at threshold, was found to depend on the anisotropy of the ystal absorption coefficient for the fluorescent transition (θ, ν) and on the anisotropy of the plate reflectivity $R(\theta)$, as ell as on the fluorescent ion concentration and maximum re- ectivity. If τ is the natural lifetime of the fluorescent state, nd n_1 and n_2 are the lower and upper fluorescent level popu- tions at the point where the material gain just balances the sses in an optimum direction,

$$w_0 \tau n_1 = n_2 \int d\Omega\, g(\theta)\, [1 - t(\theta) g(\theta)]^{-1/2} / \int d\Omega\, g(\theta).$$

was assumed for simplicity that α and R are only functions of e angle θ measured from the direction of highest gain and that

$$g(\theta) \equiv \alpha(\theta, 0)/\alpha(0, 0); \; t(\theta) \equiv [1 - R(0)]/[1 - R(\theta)] .$$

e results of numerical calculations of w_0 under various condi- ons and corrections for systems involving more than three levels re given and possibilities for control and variation of pulsa- ons were discussed.

,906 STRAIN-INDUCED EFFECTS ON THE DEGENERATE SPECTRAL LINE OF CHROMIUM IN MgO CRYSTALS by A.L. Schawlow, A.H. Piksis, and S. Sugano (Bell Labs.); Phys. Rev., Vol. 122, pp. 1469-1476, June 1, 1961

Observations of a splitting and shift of the cubic field fluorescence line at 14,319 cm^{-1} when uniaxial pressure is applied along [100], [110] and [111] directions in MgO crystals with Cr impurities are discussed. The splitting is ascribed to the removal of the degeneracy associated with the $t_2^3\, {}^2E$ excited state by the strain-induced low-symmetry crystal fields. A theoretical calculation of the splitting, assuming a point-charge model, is in good agreement with experiment. The shift is due to the isotropic part of the strain-induced crystal fields, and a simple consideration shows that the observed red shift is caused by the strain-induced change of the Coulomb interaction between the t_2 electrons. Limitations of the point-charge model adopted are discussed.

11,907 THE PHOTODIELECTRIC EFFECT IN ZnS-Cu, Co-PHOSPHORS by F.I. Vergunas and G.M. Malkin (Gor'kii Physicotech. Res. Inst.); Soviet Phys.-Solid State, pp. 2071-2076, Mar. 1961

Observations on the photodielectric effect in the ZnS-Cu, Co-phosphor at 200-5 x 10^6 cps, are discussed. The effect is due to conduction processes in crystal grains. Such processes are used to explain the range of relaxation times and dependence of the capacitance rise in dc fields on temperature and the exciting light intensity.

PHOTOELECTRONIC PROPERTIES

11,908 SPATIAL DISTRIBUTION OF TRAPPED ELECTRONS IN PHOTOCONDUCTING ANTHRACENE by W. Moore (U. North Carolina) and M. Silver (Off. Ord. Res.); Proc. Princeton U. Conf. on Semiconduction in Molecular Solids, pp. 61-68, Feb. 1961

An investigation of the distribution of trapped charge produced in anthracene is reported. It is found that there is a definite and consistent variation of the center of charge with the absorption depth of the incident radiation. This shows strongly that free carriers are produced in the bulk from excitation by the highly absorbed incident radiation. The source and mechanism of free carrier formation are not understood at present.

11,909 LOW TEMPERATURE PHOTOCONDUCTIVITY OF ADDITIVELY COLORED KCl by R.L. Wild (U. California); Bull. Am. Phys. Soc., Ser. II, Vol. 6, p. 281(A), Apr. 24, 1961

Observations that the spectral photoresponse of additively colored KCl at 10°K reflects the absorption structure found by Luty were discussed. The product of quantum yield and carrier range is nearly constant in the L_1 and L_2 band (3.6 and 4.2 ev) but drops sharply in the K and F region. This suggests that the K band (as well as the F band) results from excitations to states below the bottom of the conduction band. Partial saturation of photoconductivity vs electric field yielded carrier range estimates near 10^{-6} cm^2/v. This plus Luty's result of optical absorption proportional to F-band absorption yields 0.04 for quantum yield, indicating competing processes. The F center (or closely associated centers) is the main trap for heavily colored crystals with a trapping cross section $\cong 10^{-14}$ cm^2, but shallow traps become dominant in lightly colored crystals. For these shallow traps the product of concentration and cross section is 1000 - 4000 cm^{-1} which suggests large cross section or very high

concentration. Illumination fills these shallow traps and produces enhanced photosensitivity in the infrared region.

11,910 PRESSURE ENERGY, SOURCE OF MOTIVE POWER IN THE PRESSURE THEORY OF THERMO- AND PHOTOELECTRICITY by M. Green (Burroughs); Bull. Am. Phys. Soc., Ser. II, Vol. 6, p. 304(A), Apr. 24, 1961

The mathematical formulation of the pressure theory of the thermoelectric and photoelectric effects which is based on the hypothesis that the motive forces responsible for these effects are due to pressure gradients of holes, electrons and phonons, was discussed. For a nondegenerate semiconductor the pressures – P_p of holes, P_n of electrons - behave like ideal vapors, namely, $P_p = pkT$ etc. The energy density due to the pressure is proportional to it (3/2 P for an ideal monotonic gas) so that the flow of charge carriers down the pressure gradient, in accordance with the hypothesis $I_p = \mu_p$ grad P_p etc., constitutes a flow of energy from a region of higher energy density to a region of lower energy density (in agreement with the laws of thermodynamics). Charges flowing down the pressure gradient against an electrostatic field convert pressure energy into electrostatic energy, and conversely. Reversible equilibrium, $I_p = I_n = 0$, is governed by a conservation type equation, namely, the sum of the electrostatic energy and the pressure electromotive force energy of a charge carrier is constant, i.e., eV + kT lnp = const for holes, similarly for electrons.

11,911 RESEARCH ON SOLID STATE RADIATION-INDUCED PHENOMENA by H. Kallmann (New York U.); U.S. Gov. Res. Rep., Vol. 35, p. 796(A), June 16, 1961 PB 153 936

Three aspects of the conductivity problem are discussed theoretically: (1) static phenomena, in which an equilibrium state is reached where no electric current is flowing; (2) conductivity phenomena, where the relationship between current and external voltage and other parameters is considered; (3) current multiplication by high fields. Examples and experimental results are presented. Dark as well as photoconductivity are both attributed to an emission of positive charges (holes from the electrode). A theoretical analysis of this phenomenon is given.

11,912 THE PROBLEM OF EXCITON INDUCED PHOTOEMISSION FROM CdS by W.E. Spicer (RCA Labs.); J. Phys. Chem. Solids, Vol. 20, pp. 134-137, June 1961

Shuba has found the velocity distribution of photoelectrons from CdS to be almost independent of photon energy. He assumes that this indicates that the photoemission is due to the ionization of defect levels by excitons. It is shown here that both the velocity and spectral distributions found by Shuba can be explained by the assumption of an exponential distribution of states from which the photoelectrons are directly excited by the photons. It is concluded that a velocity distribution which is insensitive to photon energy is, in itself, not sufficient evidence for exciton induced photoemission.

ELECTROMAGNETIC PROPERTIES

11,913 EFFECT OF TEMPERATURE AND DOPING ON THE REFLECTIVITY OF GERMANIUM IN THE FUNDAMENTAL ABSORPTION REGION by M. Cardona and H.S. Sommers, Jr. (RCA Labs. Ltd., Switzerland); Phys. Rev., Vol. 122, pp. 1382-1388, June 1, 1961

Observations of 2.1 and 4.4 ev peaks in the reflectivity spectrum of germanium as a function of temperature and doping are reported. The temperature coefficient of the 2.1 ev peak is -4.2×10^{-4} ev/°K, that of the 4.4 ev peak is -1.8×10^{-4} ev/°K. Large donor concentrations give a decrease in the energy gap at the zone boundary in the [111] direction which is nearly the same as the shrinkage of the thermal gap. No shift with doping of the 4.4 ev peak was detected. The spin-orbit splitting of the valence band at the L_3 point in the zone boundary was found to be 0.18 ev.

11,914 OPTICAL PROPERTIES OF CdS MONOCRYSTALS by M.S. Brodin (Acad. Sci., UkrSSR, Kiev); Soviet Phys.-Solid State, Vol. 2, pp. 1926-1930, Mar. 1961

Measurements on the dispersion and reflectivity of CdS monocrystals at 290° and 20°K are reported. The dispersion was measured in the region where the crystals were transparent or began to absorb, the reflectivity in the absorption region up to 2800 A. The dispersion curves and the dichroism of absorption were analyzed. It was found that in the absorption region the Kramers-Kronig dispersion formula was obeyed. Variation of the reflectivity curves from sample to sample was noted.

11,915 REFLECTIVITY OF P-TYPE LEAD TELLURIDE IN THE INFRARED REGION by J.R. Dixon (U.S. Naval Ord. Lab.); Bull. Am. Phys. Soc., Ser. II, Vol. 6, p. 312(A), Apr. 24, 1961

Measurements on the reflectivity at near-normal incidence of p-type PbTe having hole concentrations varying from 3.0×10^{18} to 4.6×10^{19} cm^{-3} in the range from 3 to 32 μ were discussed. For the purest material, the reflectivity decreases regularly as the wavelength increases. In contrast, for heavily doped materials the wavelength dependence of the reflectivity is characterized by a distinct minimum followed at longer wavelength by a region of high reflectivity. For example, the reflectivity of material having a hole concentration of 4.6×10^{19} cm^{-3} is 0.47 at 3 μ, decreases to a minimum of 0.17 at 11.6 μ, and then increases to 0.82 at 32 μ. Similar results applying to other semiconductors have been reported previously by Spitzer and Fan. Such variations are attributed to the contribution of free carriers to the electric susceptibility. An analysis of the reflectivity data gives values of the susceptibility as a function of wavelength. This in turn yields a value of the susceptibility effective mass m_s of the holes. The effective masses determined in this way increase as the hole concentration increases. At hole concentrations of 3.0×10^{18} and 4.6×10^{19} cm^{-3}, m_s was found to be 0.11 ± 0.02 and 0.20 ± 0.02 m_0 respectively, where m_0 is the rest mass of a free electron.

11,916 REFLECTION AND TRANSMISSION OF CONDUCTIVE FILMS by M.V. Schneider (Swiss Fedl. Inst. Tech.); Proc. IRE, Vol. 49, pp. 1090-1091(L), June 1961

A general relation for the reflection coefficient and transmission coefficient of thin conductive films for an arbitrary angle of incidence is derived. This relation gives the first order frequency dependence term for the coefficient of reflection and coefficient of transmission, the first order correction terms in case of non-negligible displacement currents and an expression for thick conducting films.

11,917 FARADAY ELLIPTICITY IN SEMICONDUCTORS AS A FUNCTION OF THE ENERGY DEPENDENT RELAXATION TIME by J.K. Furdyna and M.E. Brodwin (Northwestern U.);

Bull. Am. Phys. Soc., Ser. II, Vol. 6, p. 302(A), Apr. 24, 1961

The theory of Faraday ellipticity in semiconductors, developed previously under the assumption of constant relaxation time τ[1], is extended to include the dependence of τ on energy. For $\omega^2\tau^2 \ll 1$, $\mu^2B^2 \ll 1$, and small losses, the ellipticity becomes

$$E = \left(\frac{\mu_0}{\epsilon}\right)^{\frac{1}{2}} t\sigma\mu B\omega \langle\tau\rangle \left(\frac{\langle\tau^3\rangle}{\langle\tau^2\rangle\langle\tau\rangle} - \frac{1}{4}\frac{\omega_p^2}{\omega^2}\right),$$

where the angular brackets denote Maxwellian averages, μ_0 is the permeability of free space, ϵ the static dielectric constant, t sample thickness, σ dc conductivity, μ Hall mobility, B magnetic field, ω frequency of the electromagnetic wave, and ω_p^2 equals $\sigma/\langle\tau\rangle\epsilon$. The value of ellipticity and the condition for change of sign thus depend strongly on the type of scattering. Effects of the energy-dependence of τ on the Faraday ellipticity were discussed for other ranges of μB, $\omega\tau$ and the dielectric loss. Comparison with the available experimental values shows that the agreement between theory and experiment is significantly improved when the energy-dependence of τ is taken into account.

THERMAL PROPERTIES

GENERAL

11,918 A COMPENDIUM OF THE PROPERTIES OF MATERIALS AT LOW TEMPERATURES (PHASE 1). Part II. PROPERTIES OF SOLIDS by V.J. Johnson (Natl. Bu. Stand.); U.S. Gov. Res. Rep., Vol. 35, p. 802(A), June 16, 1961 PB 171 619

Thermal expansion, thermal conductivity and specific heat and enthalpy are given for a number of solids of interest in cryogenic engineering. Data sheets, primarily in graphic form, are presented from best values of data collected. The source of the material used, other references and tables of selected values with appropriate comments are furnished with each data sheet to document the data presented. Conversion tables and other helpful information are also included.

THERMAL CONDUCTIVITY

11,919 TEMPERATURE DISTRIBUTION IN A CONDUCTOR ADJACENT TO A PLATE OF INFINITE CONDUCTIVITY MODEL GENERAL by R.A. Papetti (Douglas Aircraft); U.S. Gov. Res. Rep., Vol. 35, p. 802(A), June 16, 1961 PB 150 243

An exact expression which relates the temperature at the interface of two infinite slabs to time and the material properties of the two slabs is obtained for a two-zone system which is perfectly insulated on one external surface and experiences a constant heat input on the remaining surface. Two analytical models are discussed. The principal model considered has infinite thermal conductivity assigned to one zone. The more accurate representation considers the effect of finite conductivities in each zone. A comparison between the solutions for the two models is made for an aluminum-quartz system. The results of the comparison show close agreement between solutions for the two models. A Laplace transformation of the time variable in the thermal conduction equations is employed to obtain the exact temperature-relationships. The analytical results for the principal model are plotted along with the computer solutions of the same problem. The computer solutions are based on the one-dimensional Runge-Kutta analysis of thermal conduction, time-variant problems. Close agreement between computer and analytical results is obtained. This agreement supports the use of the Runge-Kutta technique in more complex systems where exact solutions are not presently available.

11,920 HEAT CONDUCTION IN ALLOYS AND SEMI-CONDUCTORS AT LOW TEMPERATURES by I. Estermann and J.E. Zimmerman (Carnegie Inst. Tech.); U.S. Gov. Res. Rep., Vol. 35, p. 801(A), June 16, 1961 PB 154 868

A method by which thermal conductivity of relatively small samples (1/8 to 1/4 in diam, 1 to 2 in long) of various materials can be measured in the temperature regions obtainable with liquid nitrogen, liquid hydrogen and liquid helium is described. Preliminary measurements on several commercial alloys (monel, inconel and stainless steel) gave Wiedemann-Franz ratios several times greater than the theoretical value of 2.45×10^{-8} watt-ohm/deg^2, the deviation being greater for annealed than for cold-worked specimens. Samples of an alloy of 90 per cent Cu, 10 per cent Ni were prepared with varying amounts of cold work and with different grain sizes. Results with these samples were similar to those obtained with monel and inconel; they confirm the hypothesis of lattice conduction and give a qualitative indication of the effectiveness of cold work in limiting lattice conduction.

11,921 RESONANCE TRANSFER OF IONIZATION ENERGY IN SEMICONDUCTORS by S. Koshino (Radiation Ctr. Osaka Prefect.) and T. Ando (Kyoto U.); J. Phys. Soc. Japan, Vol. 16, pp. 1151-1157, June 1961

The thermal conductivity of semiconductors due to the resonance transfer of ionization energy of impurity state caused by the interelectronic interaction is calculated in each of three temperature ranges — the extrinsic, the exhaustion and the intrinsic. The conductivity obtained increases exponentially with the temperature in the extrinsic range, but decreases in the exhaustion range. In the intrinsic range it increases again exponentially with the temperature when the temperature is lower than a critical point, but decreases as the temperature increases beyond the critical point. The experimental detection of conductivity is possible under an appropriate condition in the intrinsic range, while impossible for almost all other cases.

11,922 THERMAL CONDUCTIVITY OF CaF_2, MnF_2, CoF_2, and ZnF_2 CRYSTALS by G.A. Slack (GE Res. Labs.); Phys. Rev., Vol. 122, pp. 1451-1464, June 1, 1961

Measurements of the thermal conductivity of single crystals of CaF_2, MnF_2, CoF_2 and ZnF_2 over the temperature range from 3° to 300°K are reported. In this series, CaF_2 and ZnF_2 are diamagnetic, whereas MnF_2 and CoF_2 are antiferromangetic. All four crystals have nearly equal thermal conductivities at room temperature, but differ at lower temperatures. CaF_2, which is nearly isotopically pure, exhibits an exponential rise in conductivity with decreasing temperature characteristic of umklapp processes. ZnF_2 shows only traces of such umklapp behavior because its conductivity is limited by isotope and impurity scattering. Small cusps are observed in the conductivities of MnF_2 and CoF_2 at their Néel temperatures of 67° and 38°K, respectively, which indicate the presence of phonon-magnon scattering. Some experimental details concerning thermal conductivity measurements and the behavior of gold-cobalt thermocouples are also given.

11,923 THERMAL CONDUCTIVITY OF SILICON AT LOW TEMPERATURES by J.C. Thompson and B.A. Younglove (U. Texas); J. Phys. Chem. Solids, Vol. 20, pp. 146-149, June 1961

Measurements on the thermal conductivity of several single crystal Si samples over the range 2° - 200°K are reported. Conductivities as high as 35 w/cm deg were observed. The concentration of the impurities (which were p-type in all but one sample) was varied from 10^{12} cm^{-3} to 10^{16} cm^{-3}. The thermal resistance for the purest samples is due to point defect (isotope) and boundary scattering. In the less pure samples an additional resistance is observed in qualitative agreement with the predicted effects of electron-phonon scattering. Comparisons are made with existing theories.

11,924 LOW-TEMPERATURE THERMAL RESISTANCE OF N-TYPE GERMANIUM by R.W. Keyes (IBM Res. Lab.); Phys. Rev., Vol. 122, pp. 1171-1176, May 15, 1961

It is proposed that the scattering of phonons by donors in Ge at low temperatures results from the large effect of strain on the energy of an electron in a hydrogen-like donor state. A calculation of the thermal conductivity with this scattering mechanism is presented. Reasonable agreement with the following features of the observed thermal conductivity is obtained: the very large scattering power of donors, the difference between the scattering powers of Sb and As, a temperature dependence of thermal conductivity stronger than T^3, and a dependence of the scattering on number of occupied donors rather than on the total impurity concentration.

11,925 INELASTIC SCATTERING OF CONDUCTION ELECTRONS IN DILUTE SILVER-MANGANESE ALLOYS AT LOW TEMPERATURES by M.S.R. Chari (Natl. Phys. Lab., India); Nature, Vol. 190, p. 994(L), June 10, 1961

An experiment demonstrating an anomalous increase in the thermal resistivity of dilute Ag-Mn rods in a transverse magnetic field at low temperatures is described. This behavior is explained in terms of scattering contributions to the electronic thermal and electrical resistivities. The electronic component of the Lorenz parameter L_e was found to dip below the normal Sommerfield value, attain a minimum, and approach this value at temperatures close to 0°K. Since a cooperative magnetic transition is known to occur in dilute noble metal alloys with small amounts of transition metal ions in this temperature region, the spin degeneracy of the impurity ion is removed and the scattering process involving the spin flips of the conduction electron and the ion becomes inelastic.

11,926 THERMAL CONDUCTIVITY OF NORMAL AND SUPERCONDUCTING LEAD ALLOYS by P. Lindenfeld (Rutgers U.); Phys. Rev. Lett., Vol. 6, pp. 613-615(L), June 1, 1961

Measurements of the thermal conductivity of lead specimens containing 3 per cent indium, 6 per cent indium, and 6 per cent bismuth in normal and superconducting states are presented in graphic form. Addition of impurity leads to an increase in thermal resistance in both states, but near 2°K the ratio of increase in the resistance to lattice heat transport is 40 times greater in the normal state than in the superconducting state. The large change in lattice thermal resistance with impurity in the normal state depends on the presence of electrons, since it is greatly reduced in the superconducting state.

11,927 EFFECT OF MAGNETIC FIELD ON THERMAL CONDUCTIVITY AND ENERGY GAP OF SUPERCONDUCTING FILMS by D.E. Morris and M. Tinkham (U. California); Phys. Rev. Lett., Vol. 6, pp. 600-602(L), June 1, 1961

The change in the thermal conductivity of superconducting tin and indium films upon application of a magnetic field in the plane of the film is discussed. The superconducting transition in a magnetic field is second-order for films ~700 A, in contrast to the first-order transition of bulk superconductors. Experimental data indicate that the thermal conductivity does not depend upon the angle between the thermal gradient and the induced diamagnetic currents. If the observation is explained in terms of a decrease of the energy gap of the Bardeen-Cooper-Schrieffer theory with increasing field, the modified gap remains essentially isotropic. The measured dependence of thermal conductivity of thin superconducting films with magnetic field is plotted and the result is used to compute a dependence of the energy gap upon the field.

THERMOELECTRIC AND THERMOMAGNETIC PROPERTIES

11,928 THERMOELECTRIC MEASUREMENTS AT SMALL-AREA CONTACTS by M. Cutler (Genl. Dynamics); J. Appl. Phys., Vol. 32, pp. 1075-1082, June 1961

It is shown that measurement of the effects of heating a substance in the vicinity of a metal contact by means of an electrical current leads to the determination of various combinations of the thermoelectric parameters sufficient to evaluate the electrical conductivity, the thermal conductivity and the Seebeck coefficient. If the metal contact is small, radiation causes negligible error in the determination of the thermal conductivity. One of the combinations obtained directly is the thermoelectric figure of merit. Equations which relate to the heating current an observed thermoelectric voltage or change in resistance caused by a charge in temperature at a small area contact are derived. Geometric factors are found to cancel out of these equations. Quantitative relations which set limits on the effects of radiation are also presented. An experimental method which has been used for making such measurements is described, and some experimental results which permit comparison to conventional measurements are reported. Ways in which measurements of thermal diffusivity can be combined with the other measurements are also discussed.

11,929 A SURVEY OF BASIC RESEARCH IN THERMOELECTRICITY by W.W. Scanlon (Naval Ord. Lab.); U.S. Gov. Res. Rep., Vol. 35, p. 629(A), May 16, 1961 PB 154 770

The present status of research in the general area of thermoelectricity is surveyed. Thermoelectric effects in metals and insulators as well as in semiconductors are considered. As a result of this study it is apparent that even in the simplest monatomic metals such as the alkali metals, the theory is unable to account qualitatively or quantitatively for the observed behavior. Wide discrepancies are found in some of the metals which

are generally believed to approximate closely the ideal free electron behavior.

Pressure Theory of the Thermoelectric Effect - See 11,910

11,930 THE THERMOELECTRIC POWER OF MAGNESIUM-CADMIUM ALLOYS by S. Noguchi (Tokyo Metropolitan U.); J. Phys. Soc. Japan, Vol. 16, pp. 1145-1150, June 1961

Measurements of the thermoelectric power of Mg-Cd alloys relative to pure Cu at temperatures between room temperature and 300°C are reported. The measurements were made in the entire ranges of the composition and the data were analyzed by a band-model approximation to obtain some information about the band structure of the alloys in the Mg-Cd system. The thermoelectric power at 300°C as a function of composition shows a smooth trend as did earlier Hall measurements, although the result of the thermoelectric power at room temperature shows that there are three maxima and two minima, while the result of the Hall coefficient gives two maxima and one minimum. In the alloys of the composition corresponding to the ordered phase, anomalies in the thermoelectric power are observed at the transition point. The results of the thermoelectric power indicate that there is no evidence of any extinction or initiation of a band by the alloying. The situation of the Fermi level in A-overlap is discussed.

11,931 THERMOELECTRIC PROPERTIES OF Bi_2Te_3-Bi_2Se_3 ALLOYS by R.T. Bate (Battelle); U.S. Gov. Res. Rep., Vol. 35, p. 567(A), May 16, 1961 PB 153 753

Measurements of the thermoelectric properties of Bi_2Te_3-Bi_2Se_3 alloys in the lower temperature region are reported. A technique described by Putley (Proc. Phys Soc. (London), Vol. 68B, p. 35, 1955) and by Harman, Cohn and Logan (J. Appl. Phys., Vol. 30, p. 1351, 1959) was used. In this technique, the sample is suspended by fine current leads in an evacuated can. When current passes through the sample, a temperature gradient develops across it because the Peltier heat is absorbed at one end and liberated at the other. This gradient builds up until the rate of evolution and absorption of heat by the Peltier effect is balanced by conduction back through the sample and out through the leads, and by exchange of heat by radiation between the can and the sample. Since the temperature gradient produces a Seebeck potential, the voltage across the sample increases until the steady-state condition is reached. Isothermal resistivity vs temperature data for p-type Bi_2Te_3, n-type Bi_2Te_3-Bi_2Se_3 and commercial n-type Bi_2Te_3 alloys were plotted. The temperature dependence of the resistivity of the alloys was similar at high temperatures while that of the p-type Bi_2Te_3 was steeper. Figure of merit ($\alpha^2/\kappa\rho_i$, where α is the absolute thermoelectric power, κ is the thermal conductivity, and ρ_i is the isothermal resistivity) vs temperature was plotted; a decrease in Z with decreasing temperature was shown. A plot of temperature dependence of thermal conductivity showed that the commercial alloy was independent of temperature at low temperatures. Bi_2Te_3-Bi_2Se_3 alloys went through a broad maximum, and Bi_2Te_3 increased roughly as 1/T.

Thermoelectric Power of:
CaO - See 11,784
TiC - See 11,786

11,932 THERMOMAGNETIC PHENOMENA IN SEMIMETALS IN A STRONG MAGNETIC FIELD by A.I. Ansel'm and B.M. Askerov (Acad. Sci., AzSSR); Soviet Phys.-Solid State, pp. 2060-2070, Mar. 1961

The influence of the quantization of conduction electrons in a magnetic field on thermomagnetic phenomena is examined. In the quantum-mechanical expression for the electrical current, the local temperature which occurs in the electron-distribution function is considered as a function of the center of vibrations of magnetic oscillators. The Nernst coefficient and the change in thermoelectric power as a function of temperature and magnetic field is calculated in the quantum-mechanical limit.

11,933 RESEARCH ON THERMOMAGNETOELECTRIC EFFECTS IN SEMI-CONDUCTOR by P. Aigrain (Lab. Cent. des Ind. Élect.); U.S. Gov. Res. Rep., Vol. 35, p. 794(A), June 16, 1961 PB 152 199

Use of a combined study of thermomagnetoelectric and magnetoconductance effects to investigate the band structure of semiconductors is discussed. Samples of n- and p-type Mg_2Sn were prepared by varying the rate of crystal growth from the melt; n- and p-type crystals were produced by growth rates of 75° and 150°C/hr, respectively. Magnetoconductance measurements on p-type Mg_2Sn at 77°K yielded values of 910^{-2} ohm/cm and 200 cc/coul for σ_o and ρ_A, respectively. These observations, together with thermoelectric power measurements indicate that the top of the valence band is probably made up of a single isotropic valley with an effective mass of (0.14 ± 0.03) m_o. The bipolar Nernst effect of Mg_2Sn is large enough to indicate that both Mg_2Sn and Mg_2Sn-Mg_2Pb have potential value as heat detectors.

OTHER THERMAL PROPERTIES

11,934 STUDY OF THE THERMAL EXPANSION OF α-Sn, InSb, AND CdTe by S.I. Novikova; Soviet Phys.-Solid State, Vol. 2, pp. 2087-2089, Mar. 1961

The temperature dependence of the coefficient of linear expansion, α, for alpha-Sn between 30° and 220°K, approximately, and for InSb and CdTe between 30° and 350°K, approximately, is evaluated. Covalent bonding exists in all three materials; however, InSb has a small ionic component and CdTe has a somewhat larger ionic component. As the ionic component of bonding increases, the temperature, T, at which α becomes negative (and remains negative with decreasing temperature) increases; that is, for alpha-Sn, T = 45°K; for InSb, T ≃ 57.5°K; for CdTe, T ≃ 71.5°K.

MECHANICAL PROPERTIES

11,935 NOTES AND REFERENCES FOR THE MEASUREMENT OF ELASTIC MODULI BY MEANS OF ULTRASONIC WAVES

by H.J. McSkimin (Bell Labs.); J. Acoust. Soc. Am., Vol. 33, pp. 606-615, May 1961

Aspects of wave propagation of particular importance for the measurement of elastic moduli of solids are reviewed. Experimental techniques are discussed, with notes on the suitability for a given application and on factors affecting the accuracy of the results. Literature references to more detailed descriptions are given.

11,936 ELASTIC CONSTANTS OF IRON FROM 4.2 TO 300°K by J.A. Rayne and B.S. Chandrasekhar (Westinghouse Res. Labs.); Phys. Rev., Vol. 122, pp. 1714-1716, June 15, 1961

Measurements of the zero-field elastic constants of Fe from 4.2 to 300°K using the ultrasonic pulse technique are reported. Extrapolation of the data to absolute zero gives $c_{11} = 2.431 \pm 0.008$, $c_{12} = 1.381 \pm 0.004$ and $c_{44} = 1.219 \pm 0.004$, all expressed in units of 10^{12} dyne cm^{-2}. The corresponding limiting value of the Debye temperature is $\theta_0 = (477 \pm 2)°K$. Using this figure, the low-temperature heat capacity data for iron have been reanalyzed assuming the presence of a spin-wave contribution to the specific heat, i.e., the heat capacity is assumed to follow the relation $C = \gamma T + \beta T^3 + \alpha T^{3/2}$. At least squares fit of $(C - \beta T^3)/T$ versus $T^{1/2}$ gives $\gamma = (11.7 \pm 0.1) \times 10^{-4}$ cal $mole^{-1}$ deg^{-2}, $\alpha = (2 \pm 1) \times 10^{-5}$ cal $mole^{-1}$ $deg^{-5/2}$. There is agreement, within experimental error, between the latter figure and the theoretical estimate of $\alpha = 0.8 \times 10^{-5}$ cal $mole^{-1}$ $deg^{-5/2}$ obtained from the low-temperature magnetization data of Fallot. From the room temperature elastic constants, the compressibility of iron is found to be $K = (5.95 \pm 0.02) \times 10^{-13}$ cm^2 $dyne^{-1}$, which agrees exactly with the static value obtained by Bridgman.

11,937 ELASTIC CONSTANTS OF SINGLE CRYSTAL YIG by A.E. Clark and R.E. Strakna (U.S. Naval Ord. Lab.); J. Appl. Phys., Vol. 32, pp. 1172-1173(L), June 1961

Measurements of the elastic constants for a single crystal of YIG by an acoustic technique are reported. Two independent velocity measurements were made on parallel (100) and (110) faces of the single crystal. All data were taken at 23°C. A 7 Mc signal was fed to the YIG crystal through a fused silica delay line from a quartz crystal oscillator. The velocities were reproducible to ± 0.1 per cent. From the elastic constants the anisotropy factor defined as $2C_{44}/(C_{11} - C_{12})$ was of the order of unity. For YIG the elastic constants are: $C_{11} = 26.9 \times 10^{-11}$, $C_{44} = 7.64 \times 10^{-11}$ and $C_{12} = 10.77 \times 10^{-11}$ d/cm^2.

11,938 ELASTIC WAVES IN TRIGONAL CRYSTALS by G.W. Farnell (McGill U., Montreal); Can. J. Phys., Vol. 39, pp. 65-80, Jan. 1961

The propagation characteristics of sound waves in two particular trigonal crystals, α-quartz and sapphire, are calculated. The development of the eigenvalue equation for the velocity and the formulae for the components of the displacement and energy-flow vectors are summarized. The assumption that the wave has a plane wavefront normal to a given direction leads to three solutions, one representing a quasi-longitudinal wave and the other two representing quasi-transverse waves. The velocities of propagation, directions of displacement, and directions of energy flow for the three waves are calculated for many orientations of the wave normal. Detailed results for propagation near one of the pure-mode axes are presented.

11,939 EXPONENTIAL TEMPERATURE DEPENDENCE OF YOUNG'S MODULUS FOR SEVERAL OXIDES by J.B. Wachtman, Jr., W.E. Tefft, D.G. Lam, Jr. and C.S. Apstein (Natl. Bu. Stand.); Phys. Rev., Vol. 122, pp. 1754-1759, June 15, 1961

Measurements of Youngs's modulus over the temperature range 77° - 850°K by an accurate resonance technique are reported. Data are presented for single crystals of aluminum oxide with various orientations of the crystallographic axes and for polycrystalline aluminum oxide, thorium oxide, and magnesium oxide. The results show that the range of validity of a T^4 temperature dependence predicted by theory must be quite small. The temperature dependence is very well described over the whole temperature range by $T \exp(-T_0/T)$, where T_0 is an empirical parameter.

11,940 VARIATION OF THE ELASTIC MODULI AT THE SUPERCONDUCTING TRANSITION by G.A. Alers and D.L. Waldorf (Ford); Phys. Rev. Lett., Vol. 6, pp. 677-679(L), June 15, 1961

Measurements of the three elastic moduli of the cubic superconductors Pb, V and Nb are presented. These data suffice for the calculation of the Debye θ_0 energy, the zero-point energy associated with the transition from the normal to the superconducting state, and the discontinuity in the bulk modulus associated with the zero-field superconducting transition. The measurements were made on crystals of 99.9 per cent purit The differences in the elastic moduli between the normal and superconducting states are shown graphically, and it is noted that the moduli in the superconducting state are always less than in the normal state. The temperature dependence of the elastic moduli in both states is also yielded by the method of measurement. Chester's conclusion that the difference in the lattice kinetic energy between the normal and superconducting states should be comparable to the total free-energy difference between the two states is verified. The modulus most effected by the transition to superconductivity is the smallest shear modulus, which indicates that a shear stress would be most effective in changing the critical field.

11,941 CHANGE IN YOUNG'S MODULUS BETWEEN NORMAL AND SUPERCONDUCTING INDIUM by D. Bhattacharya and E.A. Stern (U. Maryland); Bull. Am. Phys. Soc., Ser. II, Vol. 6, p. 267(A), Apr. 24, 1961

Measurements of changes in the Young's modulus of a polycrystalline In bar between the normal and superconducting states, made down to about 1.0°K with a sensitivity of better than one part in 10^5, were reported. These measurements were undertaken to explain the paradox that the lattice specific heat of In in the superconducting state is roughly 20 per cent less than that of the normal state below 0.7°K, while the change in the lattice Debye temperature as determined from elastic constants at 1.4°K is less than one part in 6×10^3.

Effect of Phonon Viscosity on Acoustic Wave Attenuation - See 11,673

SOLID STATE DEVICES

DIODES

11,942 DIODES CAN DO ALMOST ANYTHING by J. H. Forster and R. M. Ryder (Bell Labs.); Bell Labs. Rec., Vol. 39, pp. 3-9, Jan. 1961

The impact of recent semiconductor technology on diode development and major trends in the expansion of diode performance are surveyed. The basic action of a p-n junction is reviewed, and the importance of junction properties such as rectification, dielectric capacitance, storage capacitance and photosensitivity is discussed.

Effect of Van Allen Belt Radiation on Diodes - See 11,969

Power Characteristics of Diodes - See 11,967

11,943 CRYSTAL DIODE ASSEMBLY AND METHOD OF MAKING SAME by J. G. Hambor and C. Weaver (Gahagen, Inc.); U.S. Pat. 2,984,890, Issued May 23, 1961

Fabrication of Ge computer diodes is discussed. Cu, or an alloy containing over 30 per cent Cu, is employed as the whisker material. The whisker is positioned upon, and in contact with, a Ge wafer, and the assembly is pulsed with high electrical currents to form the diode. Cu thermally converts the Ge adjacent to the whisker to opposite conductivity; Cu also acts to reduce the lifetime in the junction region, increasing the recovery time of the diode.

Current Mechanisms in Inversion Layers of Point Contact Diodes - See 11,817

11,944 INVESTIGATION OF SILICON CONTROLLED RECTIFIERS FOR STATIC POWER CONVERSION by G. P. Underbrink (Temco Electronics); U.S. Gov. Res. Rep., Vol. 36, p. 22(A), Aug. 20, 1961 AD 257 828

The parameters and operating characteristics of silicon controlled rectifiers (SCR) are described and the application of SCR to high power conversion is discussed. Fundamental concepts of static power conversion are established and problem areas associated with the SCR are treated. Background information leading to requirements for semiconductor static power converters and increasing demands for implementation of SCR in this field are presented. The fundamental methods for dc-ac power conversion are series, parallel, and bridge. Each of these methods is described, listing pertinent considerations related to SCR usage. The description contains mathematical expressions for load, voltage, and frequency regulation, as well as efficiency.

11,945 UNIFORM TURN-ON IN FOUR-LAYER DIODES by K. Hubner, M. Melehy, and R. L. Biesele, Jr. (Shockley); IRE Intl. Conv. Rec., Vol. 9, Part 3, pp. 30-34, Mar. 1961

Turn-on characteristics of four-layer diodes, investigated as a function of the rate of rise of the applied voltage close to the breakover point, are discussed. A very fast rate of rise permits an increase in voltage to, or greater than, the designed avalanche voltage of the center junction, even if localized spots having a lower breakdown voltage are present. Such spots may be due to crystalline defects, surface conditions, or statistical variation of impurity concentration. There is evidence that a fast rate of rise results in uniform turn-on and allows pulse current densities in excess of 50,000 amp/cm^2 without damaging the device.

Zener Diode Characteristics - See 12,206

11,946 THE EVALUATION OF "ESAKI INTEGRALS" AND AN APPROXIMATE EXPRESSION FOR THE TUNNEL-DIODE CHARACTERISTIC by T. P. Brody and R. H. Boyer (Westinghouse Res. Labs.); Solid State Electronics, Vol. 2, pp. 209-215, May 1961

A simple analytical current-voltage relationship for tunnel diodes is discussed. The relationship approximates the original Fermi-Dirac type integrals as first considered by Esaki. Two series expressions for these integrals, suitable for computations at room and low temperatures, are derived.

11,947 APPLICATIONS OF TUNNELING TO ACTIVE DIODES by N. Holonyak, Jr. (GE); U.S. Gov. Res. Rep., Vol. 35, p. 625(A), May 16, 1961 PB 153 873-2

Studies of tunneling due to states (bands) in the "forbidden gap" of GaAs and InP are reported. A reliability-failure property in GaAs tunnel diodes which bears some resemblance and possible relationship to formation of "forbidden gap" states is described and a method of regrowing and doping GaAs (and potentially other compounds) from an alloy-vapor state is outlined. Some initial results in growing various intermetallic compounds (including epitaxial growth of GaAs) via reaction with a halogen in a closed quartz tube are presented. A theoretical and experimental study of tunnel diode characteristics and their relationship to circuit performance has been undertaken. The circuits studied are: general purpose logic, sequential circuits, pulse generators and drivers, memory, and active RC filters. Results to date indicate that the practical application of tunnel diodes are limited.

11,948 ON THE SECONDARY TUNNELING PHENOMENA IN A P-N JUNCTION OF GALLIUM ARSENIDE by A. Shibata (Sony Corp.); J. Phys. Soc. Japan, Vol. 16, p. 1261(L), June 1961

Experimental evidence of the existence of secondary tunneling phenomena in p-n junctions of GaAs is outlined. Impurity bands were found in the energy gap, and tunneling between the conduction or valence bands and impurity bands appeared. I-V characteristics of a p-n junction of GaAs were observed at room and liquid nitrogen temperatures. Two very small current peaks were observed at room temperature. A similar phenomenon occurs in phosphorus-doped Ge p-n junctions, and this was confirmed. No evidence of such an effect was found in As-doped Ge backward diodes. Further junctions were investigated. Reasons for this structure are offered and conclusions with regard to the existence of impurity bands are drawn.

Tunneling Processes in Au-Doped Si Tunnel Diodes - See 11,822

11,949 THE DESIGN AND CONSTRUCTION OF TUNNEL DIODES by J. Przybylski and G. N. Roberts (Stand. Telephones Cables); J. Brit. IRE, Vol. 22, pp. 497-505, Dec. 1961

The electrical characteristics and principle of operation of two types of tunnel device – the tunnel diode and the unitunnel or backward diode – are described. The considerations governing choice of base and alloying materials are discussed. Details are given of the processes used to manufacture Ge and GaAs devices, particular attention being given to the method

of achieving close tolerance of the peak current of tunnel diodes by a monitored etching technique. Results which show the influence of processing parameters on device characteristics are presented. The equivalent circuits of the devices are related to the basic properties of the elements and their encapsulation.

11,950 TUNNEL DIODES FOR LOW NOISE AMPLIFICATION by L. Armstrong (Micro State Electronics); IRE Electron Dev. Mtg., p. 62(A), Oct. 1961

The factors influencing the negative resistance-current product of tunnel diodes (i.e., the shot noise constant K) were discussed. Design factors that can be introduced to minimize K, and limitations thereof, were reviewed. Experimental results on Ge tunnel diodes designed for low noise amplification were presented to show the correlation of experimental measurements with the theoretical considerations. A new approach to the problem of obtaining low noise constant diodes was presented. The selection of GaSb as a choice semiconductor material for low noise tunnel diodes was defended; a review of the metallurgy of this material and a general description of GaSb tunnel diode fabrication technology were presented. A summary of the results achieved to date was included.

11,951 NARROW BASE PLANAR JUNCTION PUNCH-THRU DIODE by R. H. Rediker (Research Corp.); U. S. Pat. 2,975,342, Issued Mar. 14, 1961

Methods of fabricating narrow base planar junction punch-through diodes by either controlled selective bath etching, depletion layer jet-electrolytic etching, or solid state diffusion techniques are discussed. The punch-through diodes fabricated exhibit a rapid switch from a high impedance reverse bias state to a low impedance reverse bias state at a value of applied voltage which is accurately controlled during manufacture. Because of the very small spacing between the rectifying junction and the ohmic contact, hole storage effects as well as forward switching effects are minimized enabling the punch-through diode to be used at rates up to and possibly exceeding 10 Mc. Because of the plane parallel structure, forward resistances below 5 ohms and voltage drops of less than 0.1 v can be obtained for 1 ma forward current.

11,952 X-BAND PARAMETRIC AMPLIFICATION – AN INTEGRATED APPROACH TO THE DIODE AND CIRCUIT PROBLEM by S. M. Ku, R. I. Harrison, and S. W. Harrison (Genl. Tel. Labs.); IRE Intl. Conv. Rec., Vol. 9, Part 3, pp. 129-138, Mar. 1961

Development of a point-contact GaAs varactor and the complementary circuitry for a parametric amplifier operating at X-band frequencies is described. Fabrication of the diode, techniques of characterizing its microwave properties, and dynamic tests in the amplifier are discussed. Specific reference is made to the relative importance of resistivity of bulk material, package design, pulsing, capacitance variation, etc., needed to produce a diode suitable for parametric action at these frequencies.

11,953 SILICON JUNCTION DIODES AS VARIABLE CAPACITORS by J. Registrar (G. & E. Bradley); Electronic Engrg., Vol. 33, pp. 783-787, Dec. 1961

An explanation of the physical mechanism of semiconductor junction capacitance is presented. The inherent junction capacitance is dependent on the barrier width, which is a function of the applied bias. The barrier width is analyzed, using the equivalent circuit of a semiconductor rectifier. An equation is developed to find the junction capacitance and the different methods of measurement are explained. The application of junction diodes as variable capacitors in resonant circuits, remote tuning control, automatic tuning, dielectric amplifiers, pulse circuits, and time-constant curve straightening are described.

11,954 HIGH-CUTOFF FREQUENCY GALLIUM-ARSENIDE DIFFUSED-JUNCTION VARACTOR DIODES by L. H. Gibbons, M. F. Lamorte, and A. Widmer (RCA); IRE Electron Dev. Mtg., p. 60(A), Oct. 1961

Device characteristics of GaAs diffused-junction varactor diodes were discussed. The maximum cutoff frequency (at breakdown voltage) is greater than 5×10^5 Mc, and the breakdown voltage is as high as 20 v. The geometry of the diode, the packages employed, and their electrical characteristics were presented. Design considerations were discussed in some detail. Some results obtained with parametric amplifiers employing these diodes were given.

Electrical Properties of GaAs Vapor-Grown Junctions - See 11,703

11,955 TRANSITION REGION PROPERTIES OF REVERSE-BIASED DIFFUSED P-N JUNCTIONS by J. Cohen (Hughes Prod.); IRE Trans., Vol. ED-8, pp. 362-369, Sept. 1961

Poisson's equation for two common types of diffused p-n junctions is solved. By a suitable transformation, the field in the junction and the capacitance-voltage relation for all junctions may be represented by a single family of curves with no approximation other than the assumption of negligible drift field. The abrupt and graded regions are discussed in detail. The zero-bias potential and capacitance are also discussed.

11,956 FUNDAMENTAL LIMITING NOISE OF DEPLETION LAYER CAPACITANCE by L. J. Giacoletto (Michigan State U.); IRE Intl. Conv. Rec., Vol. 9, Part 3, pp. 3-9, Mar. 1961

Semiconductor diode junction noise is discussed. The basic noise mechanism is due to fluctuations in the ionization state of the impurity atoms which occur at random, relative to the probability of ionization, $w = n_{D+}/n_D$. In an n-type semiconductor, a neutral impurity that suddenly becomes ionized releases a mobile electron whose movement forms a noise current pulse; this happens similarly for the elemental deionization event. The net result is a short-circuited noise current,

$$\overline{I^2_{wm}} \approx 2q^2 \frac{n_D AW}{\tau_{D+}} \frac{(1-w)}{w} [-q(V_B + V_C)/kT]^{-1} \Delta f.$$

Using typical numbers, this formula indicates that the fundamental noise associated with a 0.3-μμf depletion layer capacitance at 100 Mc is equivalent to the thermal noise of a 6-ohm series resistor at 40°K and 0.1-ohm series resistor at 300°K. Experimental verification of this type of noise is not yet available.

Queuing Approximation of Noise in Semiconductors - See 11,980

11,957 Ge OR Si JUNCTIONS MADE BY THE SURFACE WELD-REGROWTH PROCESS by T. C. Taylor and F. L. Yuan (Raytheon); Solid-State Electronics, Vol. 3, pp. 70-72(L), July 1961

Fabrication techniques and room temperature dc characteristics of p-n surface weld-regrowth junctions are discussed. The junctions were fabricated by the melting, wetting, and resolidification of one semiconductor on the unmelted surface of another. Junctions were formed using As- and Sb-doped Ge; tests were also made on Si junctions. Junctions fabricated by the surface weld-regrowth process are compared with those fabricated by more conventional means.

11,958 METHOD OF PRODUCING A SILICON SEMICONDUCTOR DEVICE by A. Herlet, H. Patalong, and N. Schink (Siemens AG); U.S. Pat. 2,974,074, Issued Mar. 7, 1961

A method of manufacturing semiconductor devices in which a Si crystal is fusion-joined with a contact electrode consisting of a Au-Sb alloy is described. The Sb is preferably 1 per cent of the alloy and traces of As (0.001 - 0.1%), oxidic oxygen (0.01%), and S (0.1%) are included in the alloy. Methods of adding the oxygen are discussed. An example of the formation of a p-n silicon rectifier using an alloy of Au-Sb-As-O-S to form a junction is given.

11,959 METHOD OF MAKING PHOSPHORUS DIFFUSED SILICON SEMICONDUCTOR DEVICES by L. D. Armstrong (RCA); U.S. Pat. 2,974,073, Issued Mar. 7, 1961

A method of making rectifying barriers by diffusing phosphorus into Si is described. A Si wafer is treated in the vapors of ammonium monohydrogen phosphate or ammonium dihydrogen phosphate. The vapors form a glassy phosphorus-containing surface film over the wafer and some phosphorus diffuses into the wafer. Additional phosphorus may be diffused into the wafer by heating to deepen the diffused layer. An example showing the preparation of a diode having a 2.5 mil phosphorus diffused layer in p-type Si is given.

11,960 ANALYSIS OF ATMOSPHERES IN MANUFACTURE OF ELECTRONIC DEVICES by M. J. Elkind (Bell Labs.); Bell Labs. Rec., Vol. 39, pp. 61-65, Feb. 1961

A specially designed atmospheric analyzer which can continuously analyze for the principle contaminants, oxygen and moisture, is described. The equipment is ideally suited to follow minute changes in the composition of the ambient atmosphere in device-treating facilities. This gas analyzer system can readily determine concentrations as low as one part per million, by volume, of water vapor and two parts per million of oxygen with a precision of ± 1 ppm moisture and ± 2 ppm oxygen in the range below 10 ppm. By using this analyzer, a better control of gaseous treatment processes used for the manufacture of semiconductors can be obtained.

11,961 SEMICONDUCTOR DEVICE by R. J. Andres and C. G. Thornton (Motorola); U.S. Pat. 2,986,678, Issued May 30, 1961

The fabrication of Si diodes is described. A Si wafer containing a p-n junction is plated by the electroless Ni process in regions to which contacts are to be made. The wafer is placed in a solder ribbon. Pressure is applied to the ribbon by a clamp consisting of the two electrodes and the entire assembly is heated to solder the leads to the nickel layers. The device is then etched, rinsed, coated with a silicone varnish to protect the surface, and sealed. High breakdown voltage devices can be fabricated by soldering several devices together with the p-region of one diode in contact with the n-region of another.

Etching Masks for Semiconductor Devices - See 11,986

11,962 SEMICONDUCTOR CONNECTION FABRICATION by M. Genser (IBM); U.S. Pat. 2,974,072, Issued Mar. 7, 1961

A technique of forming an alloy connection to a semiconductor crystal wherein a region of very low conductivity is positioned between an n-type recrystallized region and a p-type semiconductor crystal, forming a structure closely analogous to an N-I-P structure, is described. A vehicle metal (e.g., lead) is applied to a p-type crystal and alloyed. Under a controlled temperature decrease, a portion of the molten region is recrystallized. While still at an elevated temperature the assembly is exposed to a conductivity determining vapor (e.g., As). Reduction of the temperature causes a solidification of the molten region with a portion of the original metal serving as an ohmic contact.

11,963 SEMICONDUCTOR DEVICES by H. Nelson (RCA); U.S. Pat. 2,972,092, Issued Feb. 14, 1961

A method for providing electrical contacts to mesa devices is described. An insulating coating is deposited around each mesa. A conductive film is then applied over the top of, and in contact with, each mesa and over the top of the surrounding coating. An electrical connection may readily be made to the mesa without shorting between the mesa and the wafer. An example showing the fabrication of a tunnel diode, including low inductance mounting details, is included.

11,964 HEAT SINK AND DIODE ASSEMBLY by C. M. Akins (Marquette Corp.); U.S. Pat. 2,974,263, Issued Mar. 7, 1961

A simple and compact heat sink and diode assembly for application in a battery charger is described. The device provides proper removable and mechanical support and mounting with low electrical and thermal resistance contact to the sink. The components of the sink are so shaped that the heat is carried away in opposite directions from each diode. Large areas of heat radiating surfaces are formed over which cooling air from a fan may pass. The heat sink is supported by electrical insulators.

11,965 METHOD OF PROVIDING AN OXIDE PROTECTIVE COATING FOR SEMICONDUCTORS by S. J. Angello (Westinghouse); U.S. Pat. 2,989,424, Issued June 20, 1961

A method for providing an adherent protective coating of certain specific metal oxides to the surface of semiconductor devices is described. The protective coating consists of a finely divided powder of either red lead (Pb_3O_4), strontium chromate ($SrCrO_4$) or zinc chromate ($ZnCrO_4$) mixed into a slurry form using one of the transistor grade alcohols as a volatile vehicle. The slurry is applied by any one of the standard techniques, is allowed to remain at room temperature for a few minutes to effect complete removal of the volatile vehicle by evaporation, and is heated to a high temperature (150°-250°C), then is cooled to room temperature. An illustrative example of the method using a Si diode is included. Results show decreased leakage levels after application.

11,966 CONTRIBUTION TO A NEW TECHNOLOGICAL PROCEDURE FOR SELENIUM RECTIFIERS, REDUCING THEIR LOSSES [in Czech] by J. Cervenak (Inst. Rectifiers, Bechovice); Elektrotech. Obzor, Vol. 50, No. 9, pp. 483-487, 1961

The rectification properties of Se rectifiers are analyzed. A procedure which permits the variation and regulation of the rectifying characteristics, especially the threshold voltage, is suggested. A new rectifying system in which the threshold voltage can be decreased down to the lowest known value of threshold voltage of a cuprous-oxide rectifier is discussed. The volt-ampere characteristics of the suggested Se rectifier are given and compared with the volt-ampere characteristics of present commercial products.

TRANSISTORS

11,967 AN UP-TO-DATE LOOK AT POWER SEMICONDUCTOR LOAD CURRENT RATINGS by F. W. Gutzwiller (GE); Semicon. Prod., Vol. 4, pp. 19-22, Dec. 1961

The major considerations in the rating and application of power semiconductor devices from a load current standpoint are described. The junction temperature directly affects all ratings. Minimum temperature specifications are also important since mechanical stresses increase as the junction temperature decreases. Repeated temperature cycles set up destructive stresses and lead to thermal fatigue. The number of thermal cycles to failure is an inverse function of the temperature excursion. By means of the transient thermal resistance curve, junction temperature response for both simple and complex duty cycles can be calculated. Surge ratings should be used only for exceptional overload circumstances caused by short circuits and component failures, since the device may not be able to perform normal circuit functions immediately following the surge. Expected improvements in ratings are discussed.

11,968 SEMICONDUCTOR SWITCHING DEVICE by R. N. Noyce (Fairchild); U.S. Pat. 2,971,139, Issued Feb. 7, 1961

A four element transistor adapted for switching operation and having a switching current dependent upon controllable design parameters (i.e., substantially insensitive to surface conditions) is described. Electrical shorting of certain transistor junctions and proper selection of resistivities provide sufficiently large switching currents so that the surface leakage currents become insignificant. Complete conduction through the p-n-p-n transistor is dependent entirely upon current through the bulk resistance, making the switching point predeterminable.

11,969 THE EFFECTS OF VAN ALLEN BELT RADIATION ON MATERIAL by R. S. Shane (GE); IRE Intl. Conv. Rec., Vol. 9, Part 5, pp. 129-138, Mar. 1961

The interaction of the Van Allen belt with electronic components and materials is considered. The operating characteristics and physical properties of many semiconductor devices, capacitors, resistors and insulating materials under prolonged Van Allen radiation are discussed. The limits of present knowledge of the subject are outlined and a bibliography is given.

11,970 TRANSISTOR RELIABILITY ESTIMATED WITH THE POISSON DISTRIBUTION by C. H. Li (Genl. Instr.); IRE Intl. Conv. Rec., Vol. 9, Part 6, pp. 119-123, Mar. 1961

The use of Poisson's distribution in the determination of transistor reliability and yields is discussed. Yield data, plotted on a special graph paper against junction diameter or other variables, give a straight line graph. The slope of this line suggests the likely failure mechanism.

11,971 ON THE IMPORTANCE OF OPERATING LIFE TESTS AS COMPARED TO STORAGE TESTS OF TRANSISTORS by C. H. Zierdt, Jr. (GE); Solid State J., Vol. 2, pp. 21-27, Sept. 1961

The application of operating life tests rather than storage tests to indicate transistor reliability is suggested. The past three years' work has dramatically improved survival in storage tests, to the point that they no longer yield maximum information even in accelerated testing. On the other hand, operating tests now produce higher failure rates by different mechanisms which appear to be more closely related to use stresses. The search for lower equipment failure rates appears to warrant operating tests, despite their higher costs, to assure transistor reliability under operating conditions.

11,972 SIMPLE TRANSISTOR TESTER USES LAMP FOR INDICATOR by E. H. Sommerfield (IBM); Electronics, Vol. 34, p. 80, Sept. 8, 1961

A transistor tester designed to indicate in one simple operation whether a device had experienced a catastrophic failure, and if not, whether it could provide a minimum gain of $\beta = 20$ at 30 ma is described. A diagram of the complete tester and a brief description of the operation of the circuit are given. Transistor defects revealed by the device include: shorted C-B junction, punch through C-E, and shorted B-E junction, burned out leads, or h_{fe} (β) less than 20. The tester does not indicate junction failures that might occur above 3v. Neither can reverse base-emitter failures be detected. When fitted with an adapter probe the device can test transistors while in a circuit because of the extremely low impedances in the test circuit. Application of this device over a three month period has not allowed a catastrophic failure to pass unnoticed.

11,973 TRANSISTOR TEST SET by J. L. Moll (Bell Labs.); U.S. Pat. 2,900,582, Issued Aug. 18, 1959

A method of and an apparatus for determining the large-signal alpha cutoff frequency of transistors are described. A current pulse of relatively large and substantially constant amplitude is applied to the base of a test transistor in a grounded-emitter configuration. The resulting collector transient current wave is observed on an oscilloscope. The initial slope of this transient wave is a direct measure of the cutoff frequency.

11,974 VERSATILE AUTOMATIC SEQUENTIAL TESTER FOR TRANSISTOR SPECIFICATION TESTING by Staff (Semicon. Prod.); Semicon. Prod., Vol. 4, pp. 48-49, May 1961

A versatile automatic sequential tester for transistor specifications which is capable of 20-parameter "go-no-go" testing of 3600 transistors per hour is described. The main applications of this tester are mentioned. It is ideally suited for retest and incoming inspection departments where the devices are tested to determine whether or not they meet the specifications that have been assigned to each. The test modules and calibration check system of this tester are described.

1,975 TRANSISTOR STRUCTURES AND METHODS OF ANUFACTURING SAME by L. P. Hunter (IBM); U.S. Pat. 975,085, Issued Mar. 14, 1961

e fabrication of devices which utilize an intrinsic collector gion is described. The device may be fabricated by growing intrinsic p-type or an intrinsic n-type bar and alloying to e extrinsic material either an n- or p-type emitter. The vice may also be fabricated by diffusion techniques, starting th a wafer of intrinsic material, or by alloying to an intrin- wafer a metal containing both n- and p-type impurities. nce one impurity diffuses more rapidly than the other, both and n-type regions are formed in the intrinsic material. e devices constructed with intrinsic collectors exhibit itter input current gains greater than unity without the sadvantages of having their current gain affected by temper- ure, loading, etc.

,976 MULTI-ELECTRODE SEMICONDUCTOR DEVICES by I. Pankove (RCA); U.S. Pat. 2,974,236, Issued Mar. 7, 961

miconductor devices similar to the standard n-p-n or p-n-p ansistors but having several electrodes and capable of per- rming complex electrical functions are described. In one se a device having a double-ended input is provided by a miconductor body having a single emitter electrode, a single llector electrode and two base electrodes. Separate signals y be applied between the emitter and each base electrode. e composite signal is collected by the collector. In a second se a semiconductor body with a single emitter electrode, two llector electrodes and two base electrodes has a signal applied the emitter and a control signal applied across the device tween the two base electrodes. A field resulting from the ntrol signal serves to direct and accelerate the flow of charge rriers from the emitter electrode to a particular collector ectrode.

alysis of PNPN and PNPM Junction Transistors - See .067

,977 THE RELATIONSHIP BETWEEN EMITTER JUNCTION COVERY AND "WIGGLE" EFFECT by R. P. Nanavati (Syra- se U.) and R. J. Wilfinger (IBM); Proc. IRE, Vol. 50, pp. -86(L), Jan. 1961

e "wiggle" effect in the saturated transistor collector wave- rm is explained. The effect is attributed to the emitter junc- n becoming momentarily reverse biased upon application of e "off" pulse and subsequently returning to forward bias nditions. This relationship has been established by calculat- g the internal emitter junction voltage (excluding the volt- e drop across the experimentally determined extrinsic base sistance) from measurements made on the instantaneous base rrent; it is seen that good agreement exists between the time e emitter junction becomes forward biased and the time the llector waveform begins to recover from the "wiggle" effect. mple waveform characteristics are used to illustrate the cor- spondence between emitter and collector characteristics of e effect.

,978 THE STUDY AND DEVELOPMENT OF CLOSELY REG- ATED ELECTRIC POWER GENERATING AND CHARGING STEMS FOR U. S. ARMY AIRCRAFT by W. W. Fortner (Texas Instr.); U.S. Gov. Res. Rep., Vol. 35, p. 563(A), May 16, 1961 PB 153 933

The breakdown characteristics of junction transistors of various types are discussed. While little correlation with individual unit parameters was obtained, high correlation exists between destructive breakdown data and junction type. Special attention is paid to the relation of pulse shape and pulse energy to breakdown. Transistor protection in power generation and charging systems is stressed.

11,979 CALCULATION OF THE RISE AND FALL TIMES IN THE ALLOY JUNCTION TRANSISTOR SWITCH BASED ON THE CHARGE ANALYSIS by Y. Cho (Minn.-Honeywell); Proc. IRE, Vol. 49, pp. 636-637(L), Mar. 1961

Another version of the rise time (or fall time) equation of Ekiss and Simmons is derived. The derivation is simplified by applying the lumped charge model instead of using equations containing the time integral of the current since determination of the integral is difficult.

11,980 APPROXIMATE SOLUTION TO SEMICONDUCTOR NOISE AS A QUEUING PROBLEM by T. L. Saaty (Off. Naval Res.); Proc. IRE, Vol. 49, p. 1095(L), June 1961

The solution of noise problems in semiconductors using queuing problem techniques is discussed. Queuing problems provide insight into semiconductor noise since charge carriers may be viewed as the waiting line of a queuing operation. An approximation, valid in the range of $\rho = 0.7$ (where $\rho \equiv \lambda/c\mu$ in the Poisson equation), gives $f \sim 0.03$ (in the Fourier transform) and indicates the usefulness of queuing in low frequency noise evaluations.

11,981 SEMICONDUCTOR ASSEMBLY AND METHOD OF FORMING SAME by W. E. Taylor (Motorola); U. S. Pat. 2,971,869, Issued Feb. 14, 1961

A method of increasing the high frequency cutoff point of an alloy-junction transistor by reducing the transit time dispersion is described. The reduction is accomplished by fusing alloying metals onto the faces of a semiconductor wafer essentially parallel to the {111} crystallographic planes of the wafer. The construction of a p-n-p Ge-In transistor is described. An n-p-n junction transistor has also been developed using this method.

11,982 SEMICONDUCTOR DEVICE by E. Belmont (Bendix); U.S. Pat. 3,012,916, Issued Dec. 12, 1961

The fabrication of alloyed transistors which have high gain and good frequency cutoff is described. The devices are constructed by alloying the collector at one temperature and then alloying the emitter at a lower temperature. For example, in a Ge transistor utilizing In electrodes, the collector is alloyed at temperatures between 600° and 630°C, and the emitter is alloyed at 550°C. Additional control of penetration into the semiconductor is obtained by utilizing a collector to emitter alloy thickness ratio of 3:2. The use of this alloy thickness ratio and the two-firing temperature process results in a collector to emitter penetration ratio of 3:1.

11,983 PRODUCTION OF CONTROLLED P-N JUNCTIONS by L. D. Armstrong (RCA); U.S. Pat. 2,975,080, Issued Mar. 14, 1961

Methods of controlling the size and shape of rectifying barriers in bodies of semiconductive material using diffusion techniques are described. A thin surface layer of a given conductivity

type semiconductor wafer is converted to the opposite conductivity type. Predetermined portions of the converted layer are then removed. Subsequently, the wafer is heated to diffuse the type determining material from the remaining portions of the converted layer into the wafer. This diffusion is performed in an ambient which includes a substance capable of imparting the original conductivity type of the semiconductor to the surface of the wafer. A detailed example of the formation of an n-p-n Si mesa transistor using the above technique is included.

Determination of the Concentration Profile of Diffused Layers - See 11,690

Si Epitaxial Layers for Mesa Transistors - See 11,704

11,984 RECENT ADVANCES IN GALLIUM ARSENIDE TRANSISTORS by M. E. Jones and E. C. Wurst, Jr. (Texas Instr.); IRE Intl. Conv. Rec., Vol. 9, Part 3, pp. 26-29, Mar. 1961

Techniques for constructing an n-p-n alloy diffused mesa GaAs transistor are described. The parameters achieved to date are discussed with emphasis placed on the application of this device as a high-speed switching transistor. These parameters include the output characteristics, power gain, current gain and other h parameters, static characteristics, HF characteristics, and switching characteristics.

Grown Junctions in AlSb - See 11,691

Gas Analyzer for Device Fabrication - See 11,960

11,985 SILICON TRANSISTORS by W. A. Bosenberg (RCA); U.S. Gov. Res. Rep., Vol. 36, p. S-79(A), July 5, 1961 PB 154 481

Methods for improving Si transistor processing techniques are discussed. Special equipment designed for improving registration of contact patterns and three metalizing techniques are described. The definition of the evaporated wax layers for mesa etching was improved by using etched and electropolished stainless steel masks.

11,986 SEMICONDUCTOR ASSEMBLY METHODS by I. Feinberg and A. Avakian (Sylvania); U.S. Pat. 2,973,569, Issued Mar. 7, 1961

A method of mounting and preparing a semiconductor subassembly for incorporation into translating and transducing devices in a manner which is compatible with etching by powerful reagents is described. A semiconductor unit is covered with Au by electroplating or vacuum deposition; the semiconductor surface to be etched is left uncovered. Alternatively, the entire subassembly may be plated and the Au mechanically removed from the surface to be etched. The gold-covered portions will resist strong etchants for Ge and Si, including the standard aqueous solution of hydrofluoric and nitric acids with cupric nitrate.

11,987 SEMICONDUCTOR DEVICES INCLUDING GALLIUM-CONTAINING ELECTRODES by C. L. Carlson and H. Nelson (RCA); U.S. Pat. 2,977,262, Issued Mar. 28, 1961

Electrodes of In, Ga, and Au or Ag for use in alloyed junction Si or Ge transistors are described. Up to 10 per cent by weight of Au or Ag is included in the alloy. The inclusion of either of these two elements increases the concentration of Ga from less than 0.2 per cent by weight in an In-Ga alloy to about 1 per cent by weight and results in a stable alloy. Since Ga has a very high segregation coefficient, the recrystallized region produced by alloying the electrode to the semiconductor has a very low resistivity. Satisfactory rectification characteristics and transistor operation can be achieved with these electrodes with base wafers of resistivity as low as 0.1 ohm-cm. At high current densities, the devices exhibit superior current gain characteristics over devices fabricated with In electrodes and improved high frequency performance as a result of the reduction in resistivity of the base layer.

11,988 SEMICONDUCTOR CONTACT by M. M. Atalla and E. E. LaBate (Bell Labs.); U.S. Pat. 2,973,466, Issued Feb. 28, 1961

A method of forming a high temperature contact to a semiconductor wafer is described. The contact has a laminated structure comprising a refractory metal (preferably Cr, Rh, or Co) and a superstratum of oxidation resistant metal (preferably Au or Pt). For example, a layer of Cr evaporated onto a surface of a Si diffused wafer is covered by an evaporated Au layer. The resulting laminated structure is heated to 900°C for 30 min to form sintered regions at the interfaces of the Au and Cr layers and the Cr and Si. An oxide coating is formed at 960°C to passivate the Si surface.

Contacts to Mesa Devices - See 11,963

11,989 SEMICONDUCTOR DEVICE-AND-LEAD STRUCTURE by R. N. Noyce (Fairchild); U.S. Pat. 2,981,877, Issued Apr. 25, 1961

A method for providing improved electrical connections to various semiconductor regions is described. Double-diffused junction transistors are formed in an oxidizing atmosphere providing "disked" junctions extending to an oxidized surface. Selected portions of the oxide layer are removed to permit base and emitter contacts using "photo-resist" technique. Base and emitter leads are formed by evaporation. A multidevice structure has been fabricated by use of these techniques; the unit provides detector, filter and amplifier stages, all contained within the same assembly.

11,990 TRANSISTOR HEAT SINK ASSEMBLY by R. T. Race (Motorola); U.S. Pat. 2,984,774, Issued May 16, 1961

A heat sink providing an effective heat-dissipating structure for a semiconductor device as well as mechanical protection is described. The heat sink consists of an extruded, thermally conductive metal heat radiator having a smooth surface on which the mounting base of a power transistor may be supported in good electrical and thermal contact with the surface. Radiating fins which extend from the base portion a greater distance than the device protect the transistor from mechanical contact. Lateral ribs may be added onto the fins to increase the effective heat radiating area.

11,991 SEMICONDUCTOR DEVICE AND METHOD OF MAKING THE SAME by D. T. Kelley and R. G. Peterson (Motorola); U.S. Pat. 2,981,875, Issued Apr. 25, 1961

The use of folded straps in emitter and collector contacts to provide good heat dissipating paths is discussed. These straps are small and can be confined to a relatively small volume; they may be easily aligned during transistor assembly. Construction procedures that allow reuse of stems where the subassembly has failed are also discussed.

11,992 POWER TRANSISTOR COOLING by A. D. Abel (Minn.-Honeywell); Solid State J., Vol. 2, pp. 21-33, Oct. 1961

A detailed discussion of heat sink mounted transistors operating in the steady state is given. Interface and external thermal paths are considered since these are under the control of the transistor user. The three methods of heat transfer which are significant in power transistor cooling – conduction, convection and radiation – are discussed and appropriate data are presented. Both free and forced convection are treated mathematically. Information on mounting techniques and mounting materials is given. The performance of some conventional cooling methods is described which include: flat plates, Blinn dissipators, Wakefield semiconductor heat exchangers, Astro Dynamics heat sinks, Westinghouse thermoelectric coolers, and also unmounted transistors.

Protective Oxide Coatings for Transistors - See 11,965

11,993 TWO-TERMINAL SEMI-CONDUCTOR DEVICES HAVING NEGATIVE DIFFERENTIAL RESISTANCE by M. A. Chappey and J. H. Lantieri; U.S. Pat. 2,971,140, Issued Feb. 7, 1961

Two-terminal semiconductor devices which possess negative differential resistance and field-effect characteristics are described. The negative resistance is accomplished by forming two field-effect transistors on a single semiconductor wafer. The semiconductor body has an n-type conductivity part and a p-type conductivity part and two ohmic electrodes serving as the two terminals of the device. Two electric barrier layers, each having a region of space charges, modulate the resistance of one channel. The electric current has two paths available: one starting from the first terminal, following a first channel, meeting the second barrier layer and arriving at the second terminal; the other, starting from the first terminal, following a second channel, meeting the first barrier layer and arriving at the second terminal.

11,994 SEMICONDUCTOR FIELD EFFECT DEVICE by H. A. R. Wegener (Tung-Sol Elect.); U.S. Pat. 2,975,344, Issued Mar. 14, 1961

Methods of producing field effect transistors which have high voltage amplification, good heat dissipation, good resistance to mechanical strain and multiple mounting capability on a single supporting wafer are described. A block of semiconductor material is treated so as to make it an insulator (e.g., by diffusion of the material with Au). A second diffusion on one of the surfaces provides a thin layer of either p-type or n-type material. A small transverse section of either side of the block is then diffused to produce an opposite type material (n or p).

11,995 UNIPOLAR "FIELD EFFECT" TRANSISTOR by S. Teszner; U.S. Pat. 2,987,659, Issued June 6, 1961

Methods of fabricating field-effect transistors having either cylindrical, annular or rectangular configurations are discussed. Approximate mathematical expressions for the current of the drain electrode as a function of the potential of the electrodes and corresponding graphical representations are presented. It is shown that the absolute value of the modulating potential, necessary for complete pinch-off, is twice as small for cylindrical configurations as for annular or rectangular configurations, indicating that cylindrical configurations provide a conductance which is twice that of the alternate configurations. Dimensional and electrical characteristics of field-effect transistors are given.

11,996 MANUFACTURE OF FIELD-EFFECT TRANSISTORS by J. I. Franke; U.S. Pat. 2,997,634, Issued Aug. 22, 1961.

The fabrication of field effect transistors which have mechanically-strong, extremely narrow current channels is discussed. A projection extending out from the middle of a cylindrical n-type Ge crystal is formed and annular rectifying gate electrodes are applied on opposing sides of the projection with only a few tenths of a micron separating the electrodes. Annular ohmic drain electrodes are applied to the circumference of the Ge cylinder above and below the projection and an ohmic source electrode is joined to the periphery of the projection.

FUNCTIONAL UNITS

11,997 AN INTEGRATED SEMICONDUCTOR SHIFT REGISTER by J. T. Wallmark and S. M. Marcus (RCA); IRE Trans., Vol. ED-8, pp. 350-361, Sept. 1961

An integrated electronic device or circuit in the form of a miniaturized Ge shift register consisting of thyristor stages and minority carrier delay lines is described. Design considerations including theoretical analysis of minority carrier drift under dc and pulse conditions are presented. The most important second-order effects, such as influence of minority carrier storage, potential interaction, capacitances, and temperature, are analyzed. The register operates with shift pulses of 20 v over 10,000 ohms and a repetition rate of several hundred kc. An improved version with the stages in parallel rather than in series offers considerable advantages from a fabrication point of view, in that larger tolerances in the fabrication process may be allowed.

11,998 SEMICONDUCTIVE DEVICE by G. L. Pearson (Bell Labs.); U.S. Pat. 2,983,854, Issued May 9, 1961

An integrated device comprising two series-connected tunnel diodes is described. The inductance of the device is lower than that of two tunnel diodes connected in series. The device is fabricated from an intrinsic wafer by diffusing into the opposite sides of the wafer thin layers of opposite type conductivity and by alloying to these diffused layers appropriate alloys to form two tunnel junctions. A film of a conductive material such as Au, which covers the wafer surface except for junction regions, provides a lower resistance connection between the two diodes. Electrodes are applied to both junctions and to the conducting film. Diodes with similar or dissimilar characteristics can be fabricated. The I-V characteristic of an integrated tri-stable device utilizing two dissimilar diodes is presented.

Functional Units - See 11,989

MAGNETOELECTRIC DEVICES

11,999 THEORY AND PRACTICE OF HALL EFFECT MULTIPLIERS by G. S. Glinski and J. P. Landolt (U. Ottawa); IRE Intl. Conv. Rec., Vol. 9, Part 2, pp. 143-163, Mar. 1961

The more important side effects that must be considered in

translating the physical theory of the Hall effect into a practical embodiment of a Hall multiplier are discussed. Following a brief section on Hall effect theory, the sources of error in Hall elements are examined. First the "intrinsic" errors, such as those factors affecting the magnitude of the Hall constant, the temperature dependence of the resistivity, and the magnetoresistance and loading of Hall electrodes, are reviewed. Then the "extrinsic" errors of the Hall generator, i.e., a combination of the Hall element and the magnetic circuit, are analyzed, followed by a discussion of the "extrinsic" errors introduced by the components external to the Hall generator, but necessary for the practical analog multiplier. Considering the development accomplished to date in this area, the application of Hall effect multipliers as standard components of the electronic analog computers is expected in the near future.

12,000 USING THE HALL GENERATOR, A NEW CONTROL AND INSTRUMENTATION COMPONENT. Part II., by J. W. Motto, Jr. (Westinghouse); Auto. Control., Vol. 15, pp. 24-29, July 1961

Hall generator characteristics and application data are presented. Temperature effects on parameters are discussed and typical application techniques given. Since the Hall output voltage is a result of several variables, the Hall generator is applicable to numerous electrical and electromechanical applications. Use of the Hall generator in constant current control applications, analog multiplier applications, linear displacement functions and rotational displacement applications is discussed.

PHOTODEVICES

12,001 THERMAL PROCESSES IN SEMICONDUCTING CONVERTERS, SOLAR ENERGY PHOTOCELLS [in Russian] by M. Azizov (Phys.-Tech. Inst. AN Uzb SSR), Izv. AN Uzb SSR, Fiz.-Mate. Nauk, No. 3, pp. 68-75, 1961

The solar radiation expended uselessly in solar energy photocells is analyzed. Knowledge of the thermal losses and the relations between the different kinds of losses and the parameters which determine the photocell properties permits the elimination or at least the diminution of these losses. The temperature dependence of the reverse current in a Si p-n junction is analyzed and values of the parameters are presented. At low temperatures, the tunnel current predominates over the generation current; as the temperature rises the generation current starts to predominate.

12,002 HIGH-EFFICIENCY GALLIUM-ARSENIDE SOLAR CELLS by D. P. Bortfeld, A. R. Gobat, M. F. Lamorte and G. W. McIver (RCA); IRE Electron Dev. Mtg., p. 36(A), Oct. 1961

The geometry and fabrication of GaAs solar cells which exhibit conversion efficiencies up to 13 per cent were described. A typical I-V curve for such GaAs solar cells was shown and compared to a theoretical curve based on an experimentally determined space-charge-recombination junction current and zero series resistance in the cell. The internal power dissipation is a small fraction of the energy delivered to the load. Despite the low minority-carrier lifetimes observed in GaAs, a design with high collection efficiency was achieved. Solar cell I-V curves were also shown as a function of temperature and of light intensity. Some empirical operating data were given.

12,003 ULTIMATE SENSITIVITY AND PRACTICAL PERFORMANCE OF THE TELLURIUM PHOTOCONDUCTIVE DETECTOR by D. F. Edwards (U. Michigan); U.S. Gov. Res. Rep., Vol. 35, p. 625(A), May 16, 1961 PB 153 456

Calculations of the ultimate sensitivity and measurements of the practical performance for Te photoconductive detectors are presented. For the condition that detector sensitivity is limited by fluctuations of background radiation, the theoretical NEP (noise equivalent power) at the peak of spectral sensitivity ($\lambda = 3.4\mu$) was calculated to be 5.1×10^{-13} w. For the "best" Te detector the measured value of NEP was 3.1×10^{-13} w at the same wavelength and at the optimum chopping frequency. These values indicate that the Te photoconductive detector is background limited and thus is an ideal detector.

Photoconductor Devices for Computers - See 12,166

Effect of Recombination Characteristics on Solar Cell Efficiency - See 11,764

12,004 PHOTOVOLTAIC RESPONSE OF SELENIUM BARRIER LAYER CELLS TO X-RADIATION IN THE ENERGY RANGE OF 15-40 KEV by R. Feinberg and G. E. Rhead (Manchester Coll. Sci. Tech.); Brit. J. Appl. Phys., Vol. 12, pp. 461-464, Sept. 1961

The effect of X-ray irradiation in the 15-40 kev energy range on twenty Se barrier layer cells is discussed. The behavior of the cells and their response to light is compared. The X-ray sensitivity is found to be independent of irradiation at constant X-ray tube anode voltage, but linearly proportional to anode voltage at constant anode current. The form of transient response to X-irradiation depends on the intensity of irradiation and the previous history of cell irradiation, a time of rest of about 2 hours being required to achieve the first radiation response. The fatigue effect does not occur in the steady-state values to photovoltage and photocurrent. There is some evidence for a qualitative relationship between X-ray and optical photovoltage sensitivities of a cell, but there is no relationship between the photocurrent sensitivities.

Electroluminar Devices for Computers - See 12,166

Electroluminescent:
- Storage Units - See 12,192
- Screens - See 12,227

12,005 SOLID-STATE DISPLAY DEVICE by S. Yando (Genl. Tel. Labs.); IRE Intl. Conv. Rec., Vol. 9, Part 3, pp. 45-52, Mar. 1961

A solid-state display device consisting of a thin, flat panel of piezoelectric material, one surface of which supports an electroluminescent layer is described. Voltage pulses, applied to several electrodes suitably positioned on the periphery of the panel, introduce traveling acoustical waves into the piezoelectric material. Electric fields accompany the waves so produced and interact with the electroluminescent layer to produce a localized "spot" of illumination. The position of the "spot" is controlled by varying the relative timing of the pulses to produce either a raster or an oscilloscope pattern. Means for continuously modulating the light intensity of the "spot" are also described.

Pulsed Ruby Maser Light Amplifier - See 12,035

THERMOELECTRIC DEVICES

12,006 SOME NOTES ON THERMOELECTRIC EFFECTS. MODEL, GENERAL by L. L. Schilb (Douglas Aircraft); U.S. Gov. Res. Rep., Vol. 35, p. 788(A), June 16, 1961, PB 152 061

The basic thermodynamic principles of the thermoelectric effect are discussed. Design philosophies are suggested for both cooling and power generation. The basic thermo-physical equations have been presented for computer programming. A simple computer program for thermoelectric cooling is also included. This program will aid feasibility studies of vehicle cooling.

12,007 MEASUREMENT OF THE ELECTRICAL RESISTANCE OF METAL-THERMOELECTRIC SEMICONDUCTOR CONTACTS by G. McConnell and R. Sehr (Franklin Inst. Labs.); Solid-State Electronics, Vol. 2, Nos. 2/3, pp. 157-164, Mar. 1961

An accurate means of measuring small contact resistance in thermoelectric junctions relative to the volume resistance is described. A systematic study of different bonding techniques requires a sensitive measuring method. Several methods are discussed and a four-terminal bridge method is described in detail. This method allows one to measure contact resistances of the order of 1 micro-ohm with an accuracy of ±5 per cent. Measurements on Ni plates and unplated soldered junctions of doped Bi_2Te_3 with Cu having a contact resistance of 10 micro-ohms showed no rectification but did show a variation of almost 100 per cent in contact resistance around the periphery of the junction.

12,008 PELTIER HEAT PUMPS--APPLICATION PARAMETERS AND DEVICE POSSIBILITIES by H. F. Gibson (Diamond Ord. Fuze Labs.); U.S. Gov. Res. Rep., Vol. 35, p. 802(A), June 16, 1961 PB 171 559

Design theory and applications of Peltier heat pumps are described. Reversible Peltier heat pumps and simple refrigerators for a variety of military applications are cited. Particular emphasis is given to ordnance electronics applications.

12,009 SOME PROBLEMS IN THE DEVELOPMENT OF A COMMERCIAL THERMOELECTRIC REFRIGERATOR by T. B. Burnett, H. O. Lorch, and J. E. Thompson (English Elect.); Brit. J. Appl. Phys., Vol. 12, pp. 595-602, Nov. 1961

Two basic problems in the development of thermoelectric refrigerators, the construction of a cooling unit consisting of the thermoelectric junctions and the optimization of the complete refrigerator design to make best use of the thermoelectric material, are discussed. It is essential for the unit to achieve good thermal contact with the cooling chamber and to have good electrical contact across the p and n semiconductor bars forming each junction. A simple, accurate method for measuring the junction resistance is shown, and the relative merits of various methods of forming the cooling unit are discussed. The heat balance equations for a refrigerator which include the cooling fin system are given and the method of optimization of the design is noted.

12,010 THERMOELECTRIC POWER GENERATION by P. J. Bateman (Roy. Aircraft Estab.); Contemp. Phys., Vol. 2, pp. 302-311, Apr. 1961

Thermoelectric power generation is discussed. An efficiency of about 14 per cent is cited for existing semiconductor materials; future improvements in material properties should bring this figure to 40 per cent of that of the Carnot cycle. Thus, thermoelectric devices are unsuitable for large scale production of electric power and are limited to certain applications where suitable heat source and sink are available. Generators that have a power-to-weight ratio comparable with conventional small dc sources are feasible.

12,011 THERMOELECTRIC GENERATORS - DESIGN, PERFORMANCE AND APPLICATION by T. M. Corry and G. Spira (Westinghouse); IRE Electron Dev. Mtg., p. 40(A), Oct. 1961

The problems encountered in the construction of thermoelectric generators were discussed. A design procedure for free convection air-cooled generators was described. The performance of power thermocouples as a function of junction temperature was considered and curves depicting couple efficiency, power output, heat flux, and voltage as a function of hot junction temperature were given. The effects of varying thermocouple length on generator efficiency and generator specific power were shown graphically and methods of predicting generator performance as the number of thermocouples varies were given. Free convection heat exchangers and fossil fuel burners were discussed and a comparison between thermoelectric generator performance and gasoline-engine-driven generator performance was developed for specific tasks.

FERRO- AND FERRIMAGNETIC (FERRITE) DEVICES

12,012 TRAVELING-WAVE TUBES WITH FERRITE ATTENUATORS by F. K. Mullen (Sperry Rand); IRE Trans., Vol. ED-8, pp. 284-289, July 1961

Two TWT's which employed a ferrite isolator instead of the usual internal attenuator are evaluated. The TWT's employed different focusing techniques, one being magnetic and one electrostatic. The ferrite isolator does, in some cases, offer improvement in gain and efficiency over reciprocal attenuators. The limitations of this device are discussed together with some particular advantages it may offer for special applications. Design criteria for such isolators and the effects of the ferrite as a circuit element in TWT's are also considered.

12,013 RESONANCE ISOLATORS FOR MILLIMETRE WAVES by H. G. Beljers (Philips); Philips Tech. Rev., Vol. 22, No. 1, pp. 11-15, 1960/61

Use of the gyromagnetic resonance effect for making non-reciprocal microwave transmission devices, such as directional isolators, is discussed. In the millimeter wave bands the magnetic field strength required is extremely high (10^6 A/m for 8 mm waves and 2×10^6 A/m for 4 mm waves) and could not normally be generated with a permanent magnet of manageable proportions. Crystal-oriented anisotropic ferrites have now been developed, however, which possess in one direction a very high anisotropy field, and since the strength of this field can be deducted from the total magnetic field required, it is possible to use these materials for constructing isolators that need only a weak external field (or none at all). Resonance isolators of this type for wavelengths in the region of 8.6 mm and 4.3 mm (35 and 70 Gc, respectively) are described.

12,014 THE UNLOADED Q OF A YIG RESONATOR FROM X-BAND TO 4 MILLIMETERS by D. Douthett and I. Kaufman

(Space Tech. Labs.); IRE Trans., Vol. MTT-9, pp. 261-262(L), May 1961

Measurements of Q_u, the unloaded Q of a single crystal YIG sphere treated as a resonator, at frequencies from 9.5 to 67.8 kMc are reported. The experimental and theoretical calculation of Q_u are described. In this range, Q_u and α are found to be nearly independent of frequency, and it follows from the theory that the relaxation time cannot be taken as constant. This is in contrast with the results of Carter and Flammer for the range 2 to 5 kMc.

12,015 FERRITES WITH PLANAR ANISOTROPY AT MICROWAVE FREQUENCIES by I. Bady (USASRDL); IRE Trans., Vol. MTT-9, pp. 52-62, Jan. 1961

Materials with an easy plane of magnetization (planar anisotropy) that find application in isolators and phase shifters are discussed. The large anisotropy field that tends to keep the magnetization in the easy plane reduces the field required to cause ferromagnetic resonance, which makes the material promising for microwave applications. Equations are derived for the susceptibility, taking into account losses and a finite medium. Propagation in a longitudinal and transverse static field is considered. The location of a slab in a rectangular waveguide for minimum loss in the forward direction and the use of the material as a phase shifter are discussed. Experimental microwave data on some materials and data on an isolator and phase shifter incorporating these materials are given.

12,016 FERRITE CORE AND METHOD OF MAKING by E. W. Gorter, C. J. Esveldt, and H. van der Heide (Philips); U. S. Pat. 2,985,591, Issued May 23, 1961

Fabrication of magnetic cores for use in magnetic memories and switches is described. A mixture, containing Fe_2O_3, MgO, NiO, and CoO, is formed into a core of desired shape and size by sintering in oxygen at temperatures between 1350° and 1450°C. The sintered body is then subjected to magnetic fields at temperatures between 150°C and the Curie temperature. Cores so fabricated have $Rs_{max} \geqq 0.8$ and exhibit switching times between 10 and 20 μsec.

Hysteresis Curve Tracer for Magnetic Thin Films - See 12,217

12,017 FERRIMAGNETIC LIMITERS by J. Brown (Sperry Microwave); Microwave J., Vol. 4, pp. 74-79, Nov. 1961

The nonlinear theory of ferrimagnetism at high power levels is discussed. Characteristics of ferrimagnetic limiters are described, and experimental design procedures for subsidiary resonance and gyromagnetic coupler limiters are given. For subsidiary resonance limiters it was found that a ferrimagnetic material with a low threshold (low "spin wave linewidth") is desirable. The threshold will be further improved through using vertical slabs magnetized vertically in the waveguide and positioned across the guide so as to attain circular polarization. The thickness of the slab (for YIG material) was found to involve a compromise between a low threshold and an acceptable insertion loss. Further techniques for decreasing the threshold, such as the use of special geometries, are also described. For gyromagnetic coupler limiters, it was found that a low loss gyromagnetic coupling medium is necessary; the microwave structure is to be arranged to reduce leakage from one transmission line to the other, and the geometry is to be such that the operating frequency is to be above the critical frequency corresponding to threshold conditions.

12,018 MICROWAVE FERRITE STRIPLINE FILTER AND POWER LIMITER by J. Carter, I. Reingold (USASRDL), and R. A. Moore (Westinghouse); IRE Intl. Conv. Rec., Vol. 9, Part 3, pp. 116-127, Mar. 1961

Construction of electronically tunable band-stop and band-pass microwave filters from ferromagnetic resonators coupled to stripline or coaxial circuit elements is described. A theory for the small signal coupling including proximity effects from associated conducting planes agrees well with experiment. Measured power limiting threshold and dynamic range for ferromagnetic resonators used in transmission configurations are presented. Within the dynamic range of limiting the initial spike transient duration decreases with increasing excitation power. The limiting threshold and initial spike energy for spherical resonators of single-crystal YIG are shown to be sufficiently low for adequate crystal protection.

12,019 A FERRITE PIEZOMAGNETIC STRESS TRANSDUCER by C. E. Land (Sandia); IRE Intl. Conv. Rec., Vol. 9, Part 9, pp. 229-243, Mar. 1961

The operation of a piezomagnetic stress transducer is discussed. The theory of the stress sensitivity of the ferrite sensor and the qualitative relationship between transducer output voltage and mechanical stress are derived. The ferrite used experimentally was of Mn-Zn composition but greater sensitivity can probably be achieved using ferrites with hexagonal structure or of the spinel form with induced uniaxial anisotropy.

12,020 MICROSCOPIC CAPSULES CONTAINING MAGNETIZABLE MATERIAL by L. Schleicher and C. S. Baugman (Natl. Cash Register); U.S. Pat. 2,971,916, Issued Feb. 14, 1961

The production of microscopic capsules containing particles of magnetic materials for use in magnetic printing is discussed. Trichlorodiphenyl, black magnetic iron oxide, oleic acid, zinc stearate and dioctylphthalate are milled together. After emulsification, addition of gum arabic and dilution with water, the pH of the resulting solution is adjusted to 4.7 so that the colloid material deposits around each of the oil droplets containing the magnetic particle suspension. Formaldehyde (aqueous) is added and the temperature lowered. The colloid material gets to form capsule walls around each of the oil droplets. Another additive prevents capsular agglomeration during the final hardening step and a coloring substance is introduced.

PARAMAGNETIC DEVICES (Masers and Lasers)

12,021 MASERS AND OTHER QUANTUM MECHANICAL AMPLIFIERS by J. R. Singer (U. California); Advances in Electronics and Electron Physics, Academic Press, 1961, Vol. 15, pp. 73-162

The theory and design of seven prominent maser-types are given. They are: (1) ammonia beam masers; (2) paramagnetic atomic beam masers; (3) paramagnetic two-level solid state masers; (4) three-level solid state cavity masers; (5) traveling wave masers; (6) optically pumped masers; and (7) atomic

ydrogen masers. Maser systems at 50 kMc and higher fre-uencies are discussed. Inversion, amplification, oscillations, ocusing, and random noise in masers are created.

2,022 PARAMAGNETIC MASER OSCILLATOR ANALYSIS y S. Wang and J.R. Singer (U. California); J. Appl. Phys., ol. 32, pp. 1371-1376, July 1961

physical and mathematical description of a maser oscillator given with particular emphasis upon explaining the structure f the output waveform. Several approaches to the problem re taken. A qualitative description of the motion of the spin ector is followed by a derivation of the equations pertinent to e interaction of a tuned circuit (microwave cavity) and pre-essing spins. The resultant equation is nonlinear. Approximate lutions are obtained and plotted as output amplitude vs time. addition, the equations are solved with numerical solutions r specific experimental conditions by means of a digital com-uter. The numerical results are compared with experimental ata. The field-swept oscillator waveforms are explained by e analysis, and the steady state oscillator is also described.

2,023 CAVITY MODES IN AN OPTICAL MASER by W.G. agner and G. Birnbaum (Hughes Aircraft); Proc. IRE, Vol. , pp. 625-626(L), Mar. 1961

theoretical explanation of the action of a maser using some uorescent solid is outlined. A theory of quantum oscillators a multimode cavity is developed using a three-level system an atomic model, the atoms being pumped from the bottom vel to the top by input radiation and then making a rapid on-radiative transition to the second level. An expression r the power output is indicated and, above a certain thresh-d of pumping power, a sharp spike is found in the output ectrum. An expression for the width of the spike is given.

2,024 CROSS-RELAXATION MASERS by G.S. Bogle SIRO); Proc. IRE, Vol. 49, pp. 573-590, Mar. 1961

e available ways of using ruby, spinel, rutile, and emerald masers which amplify at frequencies small compared to their ro-field splitting frequencies are surveyed. Particular at-ntion is paid to means of taking advantage of cross relaxation ich, it is shown, can give typically a two-fold improvement maser performance. Analytic expressions for the energies e given which, to a large extent, remove the need for achine computations in the design of masers of this type.

,025 SOLID STATE MASER by H. Seidel (Bell Labs.); U. Pat. 2,976,492, Issued Mar. 21, 1961

provements which permit the simultaneous application of mp power and signal power to a maser crystal and increase e amplification of the device are described. The pump power d the signal power can be applied simultaneously by mount-g the paramagnetic crystal on a strip line which is resonant the signal frequency. The strip line is arranged so that the gnetic fields of the signal power and pump power are either rallel or perpendicular to each other in the crystal. A maser hich utilizes a distributed slow wave circuit to reduce the locity of the signal power and thereby increase the amplifi-tion of the device is described. Another maser which em-ys slow wave circuits on two opposite faces of a crystal to w both the signal power and pumping power wave velocities, d thereby increase the amplification, is also described.

Phonon Masers - See 11,876

12,026 SOLID-STATE, TWO-LEVEL, HIGH-POWER MASER by Staff, (Microwave Lab., Stanford U.); U.S. Gov. Res. Rep., Vol. 36, pp. 30-31(A), July 20, 1961 AD 256 279

Theoretical and experimental investigations on pulsed microwave generation with an RF input signal are reported. Initial tests were run on two models of the pulsed generator, using a disk-shaped sample without an RF input signal, without success. Equations describing the motion of the magnetization in the disk-shaped sample under the influence of a transient magnetic field, whose amplitude and direction change with time, were programmed on an analog computer. Development of components for a K-band, high-efficiency generator, using an X-band RF input signal, is described. The first model of a low-pass filter using a nonlinear dielectric element for this generator was tested and the results show a stop-band without spurious responses. The corona problem on the 100 kilo-gauss pulse field apparatus also is discussed.

12,027 MICROWAVE MASER AMPLIFIER by R.W. Damon (GE); U.S. Pat. 3,013,214, Issued Dec. 12, 1961

A technique for increasing the amplification time and producing a constant gain in a two level maser is described. Two paramagnetic ions, an isotropic ion and an anisotropic ion, are used in the maser crystal. A movable magnet is positioned at first so that the resonant frequencies of the two ions are different. At the end of the relaxation time of the isotropic ions, the magnet is moved so that the resonant frequencies of the two ions coincide. In this condition, the anisotropic ions remove energy from the isotropic ions and increase the rate of achieving thermal equilibrium.

12,028 THREE LEVEL MASER by H.E.D. Scovil (Bell Labs.); U.S. Pat. 2,981,894, Issued Apr. 25, 1961

A negative temperature medium for reducing the spin-spin resonance broadening to optimize the relaxation time between transitions of a selected pair of spins is described. The medium is a composite crystal including a diamagnetic diluent, an active paramagnetic salt capable of having at least three discrete energy levels and a doping paramagnetic salt capable of having at least two discrete energy levels whose separation can be substantially matched to the separation of a chosen pair of the three levels of the active paramagnetic salt. Typically, lanthanum ethyl sulphate is the diluent, the isomorphous gadolinium salt is the active paramagnetic salt, and the isomorphous cerium salt is the doping agent. Experimental results using pumping frequencies of 17.5 kMc and a field intensity of 3000 oe show amplification at 9 kMc.

12,029 THE DUAL CHANNEL 2390-Mc TRAVELING-WAVE MASER by R.W. DeGrasse, J.J. Kostelnick, and H.E.D. Scovil (Bell Labs.); Bell Sys. Tech. J., Vol. 40, pp. 1117-1127, July 1961

The design of dual channel maser amplifiers is described. Reflected 2390 Mc signals from the Echo I satellite have been received by a horn-reflector antenna and amplified by solid state traveling-wave masers. Each maser has sufficient gain (>3 db) to override the noise of the following stage. Unconditional stability is obtained by the use of distributed ferrimagnetic isolator elements. Their instantaneous bandwidth is 13 Mc, centered at 2390 Mc. The effective input noise temperature is 8°K.

12,030 TUNABLE S-BAND TRAVELLING-WAVE MASER FOR TELEMETRY SYSTEMS by S. Okwit, J. G. Smith, and F. R. Arams (Airborne Instr. Lab.); Proc. IRE, Vol. 49, pp. 1078-1079(L), June 1961

A ruby traveling wave maser with $6\frac{1}{2}$" active length of structure, electronically tunable over 2120 - 2370 Mc, with a net gain of 30 db and an amplification bandwidth of 21 Mc, is described. The range of operating parameters, incident pump power required for saturation, net forward gain and reverse loss of the maser are given. A slight hump on the high frequency side of the amplification band is reported.

12,031 TRAVELING WAVE SOLID STATE MASERS by R. W. DeGrasse and E. O. Schulz-DuBois (Bell Labs.); U. S. Pat. 3,004,225, Issued Oct. 10, 1961

Masers which exhibit high gain in a short length of active material, high stability, bandpass characteristics, and no interference between pump and signal are described. One maser utilizes alternate blocks of lanthanum ethyl sulphate containing approximately 0.5 per cent gadolinium ethyl sulphate and approximately 0.2 per cent cerium ethyl sulphate, and a dielectric material which has a dielectric constant close to that of the active material. The alternate blocks of active material and dielectric are mounted on a slow wave structure of copper-plated tungsten rods in a waveguide. A polystyrene bar is placed on the other side of the slow wave structure. Yttrium iron garnet isolators are imbedded in the polystyrene bar at local ions equidistant from an adjacent pair of rods in the slow wave structure. The isolators provide a high degree of stability to the device. Narrow bandwidths can be achieved by increasing the spacing between adjacent rods or by decreasing the spacing of the rods from either, or both, the top and bottom walls of the waveguide.

12,032 TRAVELING-WAVE MASER WITH INSTANTANEOUS BANDWIDTHS IN EXCESS OF 100 MC by S. Okwit and J. G. Smith (Airborne Instr. Lab.); Proc. IRE, Vol. 49, p. 1210(L), July 1961

An S-band traveling-wave maser with 126 Mc bandwidth (center frequency = 2280 Mc) and a gain of 16 db is described. The maser used a comb-type slow-wave structure loaded on both sides of the comb with $6\frac{1}{2}$" of X-ray oriented ruby of 0.05 per cent chromium concentration. The broad bandwidth was obtained by stagger-tuning the applied external magnetic field, causing the imaginary part of the magnetic susceptibility to broaden and take on a new effective shape dependent upon the distribution of the magnetic field. Field staggering was accomplished by periodically shimming one pole piece of an electromagnet with thin rectangular slabs of high-permeability material. Two different stagger-tuned field configurations, either of which provides desirable low-noise performance, are discussed.

12,033 THERMAL MASER by E. O. Schulz-DuBois and H. E. D. Scovil (Bell Labs.); U.S. Pat. 3,015,072, Issued Dec. 26, 1961

Solid state masers in which negative temperatures are obtained by thermal means are discussed. A rod of Al_2O_3, the central portion of which is Cr-doped, is used as the active material in a pulsed maser. One end of the Al_2O_3 rod is kept in contact with a heat reservoir such as liquid helium and the other end is intermittently heated. The thermal relaxation time of the Cr-doped Al_2O_3 is shorter than the spin lattice relaxation time. As a result, alternately heating the rod and then cooling it to the temperature of the liquid helium reservoir results in a negative temperature between energy levels in the active material. A maser for continuous operation, constructed by placing a rod containing regions of frequency-dependent thermal conductivity between two heat reservoirs, is also described.

12,034 LASERS: DEVICES AND SYSTEMS. Part I. by S. Vogel and L. H. Dulberger, Staff; Electronics, Vol. 34, pp. 39-47, Oct. 27, 1961

The fabrication and operation of solid-state lasers, as well as a history of the development of lasers, are discussed. Internal heating of the laser material has been one of the factors preventing CW operation of solid-state lasers. The effect of cooling the laser is described. Gaseous laser operation is also discussed.

12,035 THE PULSED RUBY MASER AS A LIGHT AMPLIFIER by P. P. Kisliuk and W. S. Boyle (Bell Labs.); Proc. IRE, Vol. 49, pp. 1635-1639, Nov. 1961

Using two pulsed ruby masers, one for the signal source, the other as a light amplifier, a power amplification of a factor of two for visible light is reported. The signal source ruby is a rod 0.2 in. in diameter and 2 in long of about 5 per cent Cr by weight; one end is silvered opaquely and the other end is silvered to allow a transmission of roughly 5 per cent. The amplifying ruby is similar to the source ruby except that it is not silvered. Gain is measured by comparing the output to input ratio with the amplifier in place to that recorded when the amplifier is completely removed from the beam. At the highest outputs of the oscillator maser it was possible to saturate the gain so that reduced gain was observed (approximately 1.3 where 2.0 was obtained at lower levels). The behavior of the measured gain with temperature and pumping power is consistent with the theory given.

12,036 SELF-ALIGNING FABRY-PEROT INTERFEROMETERS FOR USE AS LASER RESONATORS by G. Gould, S. F. Jacobs, P. Rabinowitz, and T. Shultz (Tech. Res. Group); J. Opt. Soc. Am., Vol. 51, p. 1467(A), Dec. 1961

The use of retrodirective properties of cube corners and roof prisms to relax alignment tolerances of a Fabry-Perot interferometer was discussed. Devices of both types have been constructed and their characteristics as resonators and interferometers have been investigated.

12,037 RESEARCH BREAKTHROUGHS IN OPTICAL MASERS AND SUPERCONDUCTORS by Staff, Bell Labs. Rec., Vol. 39, pp. 83-86, Mar. 1961

The achievement of a continuously operating optical maser and the feasibility of constructing a superconducting electromagnet with an ultra-high magnetic field are discussed. The new kind of optical maser uses a gaseous discharge to achieve continuous operation. The spectral line width of the output beam is a hundred thousand times narrower than that from other coherent light sources. The applications of this gaseous optical maser are discussed. The compound used for constructing the superconducting solenoids is composed of niobium and tin (Nb_3Sn) which is fabricated and reacted by special metallurgical techniques. In the wire form, the Nb_3Sn is superconducting in fields of 88,000 gauss, while carrying currents of over 150,00

amperes per square centimeter. The applications of this new development are discussed.

12,038 OBSERVATION OF OPTICAL MASER OSCILLATION IN RUBY by K. Kubota and K. Hayashi (Nippon Elect.); J. Phys. Soc. Japan, Vol. 16, p. 2063(L), Oct. 1961

Stimulated emission observed from ruby is discussed. The experiments were performed on two rods cut from Linde Al_2O_3 containing 0.05 per cent Cr_2O_3. One rod (sample 1), 4 mm in diameter and 40 mm long, was silver coated at both ends, which were parallel to 20 seconds. The other rod (sample 2), 5.5 mm in diameter and 40 mm long, had ends which were parallel to within 25 seconds. One end of sample 2 was coated with layers of CeO_2 and MgF_2, and the other end was coated with layers of ZnS and MgF_2. Pumping was accomplished by means of a home-made spiral xenon flash tube. An intense beam of red light ($\lambda = 6943$ A) was emitted from the end of the rod when the energy discharged through the lamp exceeded 850 joules in sample 1 and 1020 joules in sample 2. After exciting the samples several times, the characteristics of the films changed, and the threshold energies increased to 1200 joules in sample 1 and 1600 joules in sample 2. It is suggested that the efficiency can be improved by utilizing samples in which the c-axis lies in the direction of the rod and by cooling the rod or the lamp.

Frequency Modulation of a Ruby Optical Maser - See 11,875

Noise in Masers - See 12,070

12,039 ZERO-POINT ENERGY AS THE SOURCE OF AMPLIFIER NOISE by A. E. Siegman (Stanford U.); Proc. IRE, Vol. 49, pp. 633-634(L), Mar. 1961

Another derivation of the noise temperature of a maser amplifier is given. According to this view, noise arises from the amplification of the zero-point energy coming from the input line.

12,040 LASERS: DEVICES AND SYSTEMS. Part II. by L. Dulberger and S. Vogel, Staff; Electronics, Vol. 34, pp. 40-44, Nov. 3, 1961

Applications of laser systems to space communications and distance ranging are described. The extremely tight beams produced by a laser can travel extreme distances with little divergence. The spectral narrowness allows a good signal-to-background ratio with antennas only inches across. Two systems within reach of our present technology are discussed. Experiments have proven that light beams can be modulated. A study is in progress to use sunlight to excite a laser, providing free-power transmission. A possible communication system using a laser transmitter and a laser amplifier receiver is described. Because of its highly collimated beam, a laser search unit can get recognizable returns from greater distances than radar units. A recently developed ruby laser ranging system uses one kw pulses to determine distances up to seven miles. Communication within the earth's atmosphere must overcome atmospheric attenuation. An undersea laser system is also discussed.

12,041 LASERS: DEVICES AND SYSTEMS. Part III. by S. Vogel and L. Dulberger, Staff; Electronics, Vol. 34, pp. 81-85, Nov. 10, 1961

Applications of laser devices to military and computing fields are described. A suggested laser missile-kill system would use the intense heat produced by a concentrated laser beam. A spot on a carbon block has been heated to 8000°C in 0.5 msec in experiments. An optical computer, using a laser memory section, would provide transmission of information along optical fiber light guides without cross-talk or noise. A possible configuration using two lasers as a memory unit is described. Laser modulation, demodulation and mixing techniques are described. Amplification of laser outputs, using ruby and gas lasers, by a factor of two has been achieved.

12,042 LASERS: DEVICES AND SYSTEMS. Part IV. by L. Dulberger and S. Vogel, Staff; Electronics, Vol. 34, pp. 54-57, Nov. 24, 1961

Scientific and medical applications of lasers are described. The RF output of a maser can be used as a frequency standard with an accuracy of one part in 10^8. Successive doubling of the standard frequency will provide a chain of accurate standards through the RF, infrared and optical spectrum. The use of lasers in spectroscopy is considered and a possible arrangement for a Michelson-Morley experiment is suggested. Medical applications of lasers are discussed and the cost and availability of lasers is covered.

12,043 AN EXPERIMENTAL LASER RANGING SYSTEM by D. A. Buddenhagen, B. A. Lengyel, F. J. McClung, and G. F. Smith (Hughes Res. Labs.); IRE Intl. Conv. Rec., Vol. 9, Part 5, pp. 285-290, Mar. 1961

An experimental ranging system utilizing a ruby laser is described. A xenon flash tube excites the ruby which emits at 6943 A. The beam is collimated to 0.4 milliradian width. The receiver uses a 5 in telescope, appropriate Wratten filter and photomultiplier sensor. Test data indicate satisfactory operation during daylight hours up to 3000 yd and up to 11,200 yd at night. The laser was operated at room temperature with a power output of 600 w; 2000 w outputs were achieved during tests carried out at 210°K. A theoretical discussion is included.

12,044 A HIGH-RESOLUTION AMMONIA-MASER-SPECTRUM ANALYZER by J. A. Barnes and L. E. Heim (Natl. Bu. Stand.); IRE Trans., Vol. I-10, pp. 4-8, June 1961

A quartz crystal oscillator phase locked to an ammonia beam maser to give a sufficiently monochromatic signal is described. The device enables the measurement of power spectra of other crystal oscillators multiplied from 1458 to 145,800 times in frequency. Perturbing effects of amplifiers introduced in the early stages of multiplication were observed. It was found that, for maximum purity, dc filaments on the oscillator and early stages of multiplication were essential. With this system it was possible to investigate sidebands and noise of various oscillators and to determine which oscillators were most suited for precise frequency measurements with the National Bureau of Standards atomic frequency standards.

12,045 OPTICAL MASERS AND MICROGRAPHY by J. S. Courtney-Pratt (Bell Labs.); Bell Labs. Rec., Vol. 39, pp. 142-143, Apr. 1961

The use of the focused light beam from a ruby optical maser as a light source in micrography is discussed. The focused beam is particularly suited for use in micrography since it has a very high specific brilliance. The specific brilliance of

the focused spot is 10^4 times greater than that of an image of the sun. An experiment in which a maser light source was used to photograph potassium titanate crystals 1 to 2μ in diameter is described and a photomicrograph of the crystals is presented. The light from a ruby maser has other applications in micrography and photography (e.g., in interferometry).

OTHER SOLID STATE DEVICES

12,046 SILICON OXIDE CAPACITOR by O. B. Cecil (Texas Instr.); IRE Intl. Conv. Rec., Vol. 9, Part 6, pp. 166-173, Mar. 1961

A new miniature capacitor which utilizes thermally grown silicon dioxide as the dielectric is described. Packaged in a 0.095" diam x 0.250" length epoxy package, the device has capacitance values which range from 10 to 150 pf and is rated at 50 v over the temperature range 10 to 55°C. The capacitor has dissipation factor values of <0.002 at 1 Mc and a rated temperature coefficient of capacity ≤ ± 100 ppm/°C over the operating temperature range. Life-test data for 3000 hours indicate a low failure rate. More complete electrical characterization data are given. The potentialities of this device are discussed with respect to microminiature design and other possible packaging approaches.

12,047 THIN-FILM CAPACITORS USING TANTALUM OXIDE DIELECTRICS PREPARED BY REACTIVE SPUTTERING by P. Lloyd (Roy. Radar Estab.); Solid-State Electronics, Vol. 3, pp. 74-75(L), July 1961

A method of making small capacitor elements of the thin-film type is described. A thin film of Ta oxide is interposed between two Al-film electrodes, the whole structure being supported by a suitable substrate. The Al-film electrodes comprise the plates of the capacitor and the TaO is the dielectric. Test capacitors have given capacitance values of 0.1 μf/cm^2 and have shown tan δ values of less than 0.01 up to 30,000 cps. Frequency characteristics are plotted for dissipation factor and capacitance. Unprotected films have withstood dc breakdown voltages up to 14 for an 1800 A film.

12,048 AMPLIFIER by W. C. Dunlap, Jr. (Bendix); U.S. Pat. 2,979,668, Issued Apr. 11, 1961

A superconducting amplifier which utilizes a semiconductor having a graduated density of impurity atoms is described. The graduated impurity density permits controlled breakdown, resulting from impact ionization, with a proportional decrease in resistance. A magnetic core, with the semiconductor between the pole pieces, is held at 4°K. The semiconductor is in series with the power supply and the load. A dc bias is applied to the core. The input signal is applied to another winding and opposes the bias field, resulting in a reduction of the magnetic field proportional to the input magnitude. Reduction of the magnetic field increases the semiconductor breakdown and reduces its resistance, increasing current flow in the load.

Superconducting Solenoids - See 12,037

BaTi Pressure Transducers - See 12,220

Pressure Transducers for Medical Applications - See 12,148

12,049 NEW HIGH-FREQUENCY ULTRASONIC TRANSDUCER by Staff, (Bell Labs.); Bell Labs. Rec., Vol. 39, p. 146, Apr. 1961

An efficient device for converting electrical energy into ultrasonic energy and vice versa at microwave frequencies is described. The device is a piezoelectric transducer utilizing the depletion layer of a semiconductor. It may be applied in ultrasonic delay lines and also can be used as a tool for studying the acoustical properties of materials at ultrasonic frequencies. The advantages of the depletion-layer transducer over an ordinary transducer are mentioned.

12,050 TESTING TECHNIQUES FOR HIGH FREQUENCY QUARTZ CRYSTALS by E. W. Kentley (Cathodeon Crystals, Ltd.); Brit. Commun. Electronics, Vol. 8, pp. 748-752, Oct. 1961

Factors affecting the performance and recommended methods of specifying crystal units are discussed. Methods of producing quartz crystals are briefly described. The equivalent circuit for quartz crystal units is given and their application in oscillator circuits is schematically illustrated. Specifications of importance for the crystals are: frequency and tolerance, minimum activity required (maximum equivalent series resistance or minimum equivalent parallel resistance), operating temperature range, drive level, circuit condition (series or parallel resonant), holder style, and special requirements. Standard crystal test sets and electrical and mechanical test methods are described.

BASIC SOLID STATE DEVICE CIRCUITS

GENERAL

12,051 ACTIVE NETWORKS: PAST, PRESENT AND FUTURE by J. G. Linvill (Stanford U.); U.S. Gov. Res. Rep., Vol. 35, p. 578(A), May 16, 1961 PB 148 411

The development of the field of active networks is reviewed. The decade of the forties saw the full-scale development of the feedback system and the assessment of the limitations inherent in the parasitic elements that always accompany active components. The problem of realization of low-drift structures in the presence of drifting elements was attacked. The first encounter of the network theorist with elements that refuse to behave like a simple model brought new ideas and approaches. The fifties was the decade of the transistor. The transistor, less capable of simple representation than its predecessors, offered new capabilities to reward the network designer. The physicist and network theorist, each being now more dependent on the other, have been drawn together. Many of the old problems have been re-solved without the earlier simplifying assumptions. The pressure to make more complex, more compact and faster systems bids to make the sixties the decade of integration of the device with the circuit. The key problems inherent in this area are just now emerging. Their solution will depend on certain foundation lines drawn earlier, but with detailed character that is new.

12,052 ARBITRARY DELAY EQUALIZATION UTILIZING DIGITAL COMPUTER, IBM 704 by L-H. Shang Cheo (U. California); U.S. Gov. Res. Rep., Vol. 36, p. S-27(A), July 20, 1961 PB 150512 $4.60

Network synthesis, beginning with a given specification of the behavior of the network as a function of frequency, is discussed. From this given specification, a network function is found, then the physical network can be realized. The task of obtaining the network function from the given specification is termed an approximation. A method is used to solve any delay problem by applying the least squares technique, in which the IBM 704 is utilized to serve the iteration purpose.

12,053 METHODS FOR THE SIMPLIFICATION OF TRUTH FUNCTIONS [in German] by J. Weinmiller (Telefunken Gmbtt, Konstanz); Elektron. Rechenanl., Vol. 3, pp. 123-129, June 1961

A simplification of the truth functions employed in the synthesis of digital computer logic circuits is presented. Minimum expenditure, e.g., diodes, in the verification of the truth functions is desired. Some important methods are described and an especially useful variation of these methods is given, permitting the treatment of functions with up to 12 variables. Special emphasis is placed on the examples illustrating each method.

12,054 SOLVING STEADY-STATE NONLINEAR NETWORKS OF "MONOTONE" ELEMENTS by G. J. Minty (U. Michigan) IRE Trans., Vol. CT-8, pp. 99-104, June 1961

The problem of finding the steady-state currents and voltage drops in an electrical network of two-terminal elements, the current-vs-voltage-drop graph of each element being a curve going upward and to the right, is discussed. (Thus, "tunnel diodes" are excluded, but nonlinear resistances, current and voltage sources, rectifiers, etc. are permitted.) The construction methods are specifically designed for digital computation techniques (either automatic or manual). The principal tools are: 1) the application of theorems from graph theory ("network-topology"), and 2) quantization of the variables (permitting them to take on only a discrete set of values).

12,055 ON THE APPLICATION OF LYAPUNOV'S SECOND METHOD TO THE SYNTHESIS OF NONLINEAR CONTROL SYSTEMS by A. Stubberud, C.T. Leondes, and M. Margolis (U. California); U.S. Gov. Res. Rep., Vol. 36, p. S-33(A), Aug. 20, 1961 PB 155 308 $1.60

An approach to the design of nonlinear compensation networks is presented. The design procedure is based on Lyapunov's second method, a method of examining the stability of a set of differential equations. A Lyapunov function is formed for the control system under question, and this function is then manipulated to minimize the system settling time. A method for generating Lyapunov functions for a particular class of feedback control systems is described. Some examples of the design procedure are presented. The chief merits of the design procedure are: 1) the nonlinear system which is determined will not introduce instability into the system; and 2) the nonlinear differential equations of the system need not be solved, thus eliminating many of the computational difficulties associated with nonlinear design.

12,056 A UNIFIED APPROACH TO TWO-TERMINAL NETWORK SYNTHESIS by P. M. Kelly (Ford); IRE Trans., Vol. CT-8, pp. 153-164, June 1961

A common mathematical basis for the several methods of synthesizing driving point immittance functions is developed in terms of the reflection coefficient concept. A conceptually basic method of synthesis which has important implications in exact and approximate synthesis techniques is described. Consideration of the practical shortcomings of this method lead directly to the standard methods of exact synthesis which are demonstrated to be all applications of the Schwarz lemma. Among the methods considered are those of: Foster, Cauer, Miyata, Brune, Bott-Duffin, Fialkow-Gerst, and Darlington.

12,057 SYNTHESIS OF TRANSFORMERLESS ACTIVE N-PORT NETWORKS by I. W. Sandberg (Bell Labs.); Bell Sys. Tech. J., Vol. 40, pp. 761-783, May 1961

A theorem pertaining to the synthesis of transformerless active N-port networks is derived. The theorem: an arbitrary symmetric N X N matrix of real rational functions in the complex-frequency variable (1) can be realized as the immittance matrix of an N-port network containing only resistors, capacitors, and N negative-RC impedances and (2) cannot, in general, be realized as the immittance matrix of an N-port network containing resistors, capacitors, inductors, ideal transformers, and M negative-RC impedances if $M < N$. The necessary and sufficient conditions for the immittance-matrix realization of transformerless networks of capacitors, self-inductors, resistors, and negative resistors follow as a special case of the theorem.

12,058 STABILITY MARGINS AND STEADY-STATE OSCILLATIONS OF ON-OFF FEEDBACK SYSTEMS by E. V. Bohn (U. Brit. Columbia, Can.); IRE Trans., Vol. CT-8, pp. 127-130, June 1961

A general method, which replaces the exact methods of determining steady-state oscillations in feedback systems incorporating one nonlinear element of the ON-OFF type developed by Hamel and Tsyppkin, is described. This method overcomes certain limitations (i.e., non-general applicability) and suitable stability margins are derived.

12,059 A GENERAL STEADY-STATE ANALYSIS OF POWER-FREQUENCY RELATIONS IN TIME-VARYING REACTANCES by R. G. Smart (U. New South Wales); Proc. IRE, Vol. 49, pp. 1051-1058, June 1961

The power transfers of a time-varying reactance are analyzed. Steady-state energy relations which apply under very general conditions to varying reactances, including linear, nonlinear, static and electromechanical systems, are established. These relations include the Manley-Rowe results as special cases and provide a useful description of the external characteristics of varying (and fixed) reactances. An "energy coefficient" which specifies the behavior of an individual frequency transformation is derived. The modes in which an individual transformation can operate are described and the results are related to the characteristics of a wide range of varying reactance devices. An example of the application of the theory is given. This theoretical analysis is a basis for digital computer studies of varying reactance systems, since it provides both an over-all description of general characteristics and a means of numerical analysis of particular devices.

12,060 POWER CONVERSION WITH NONLINEAR REACTANCES by E. D. Torre and M. D. Sirkis (Rutgers U.); IRE Trans., Vol. CT-8, pp. 95-99, June 1961

The importance of the nature of the nonlinearity in mixing processes occurring in nonlinear reactances, particularly those having characteristics that can be represented by a power series, is pointed out. Power relationships are derived, and limitations imposed by a finite degree of nonlinearity are considered. Restrictions on the source frequencies are found, and it is shown that in practice incommensurability is not required. The special cases of harmonic generation and subharmonic generation are considered. For the case in which this circuit is identical to that analyzed by Manley and Rowe, the results obtained agree with theirs.

12,061 EFFECT OF CIRCUIT DESIGN ON SYSTEM RELIABILITY by J. J. Suran (GE); IRE Trans., Vol. RQC-10, pp. 12-18, Mar. 1961

The effect of circuit design tolerances on over-all system reliability is discussed. Circuit drift failures may be eliminated by worst-case design procedures but a considerable price is paid for this immunity in the form of increased system complexity, increased component stresses and increased power demand. Consideration of the entire problem leads to the conclusion that decreasing the probability of circuit drift failures (by increasing the tolerance margin of the circuit) tends to increase the probability of component catastrophic failures and that consequently an optimum component tolerance design point exists for maximum system reliability. The optimum tolerance margin depends upon the specific system and generally varies inversely with the number of components comprising the system. Thus, to maintain a specified system reliability in the face of increasing system complexity, it is necessary to assume a decreasing component parameter spread (tighter tolerances) and a decreasing component catastrophic failure rate. Both of these requirements may be relaxed if some form of redundance is introduced to overcome the inevitable occurrence of catastrophic failures.

12,062 STEP-BY-STEP DESIGN TECHNIQUES FOR MULTILAYER THIN-FILM NETWORKS by W. W. Carroll and F. F. Jenny (IBM); Electronics, Vol. 34, pp. 90-93, May 19, 1961

The technique of fabricating multilayer thin-film passive networks is described. The operational performance of these thin-film networks is determined and compared with that of conventional networks. Glass 0.020 in thick is used as substrate material. Aluminum is chosen for conductor, nichrome for resistor and silicon monoxide for dielectric and insulator material. Wire leads are thermocompression bonded to the film-interconnecting tabs. The results of environmental tests of several hundred circuits are also included.

Tunnel Diode Circuits - See 11,947

12,063 THE TUNNEL DIODE PAIR by D. J. Hamilton and M. J. Morgan (U. Arizona); Semicon. Prod., Vol. 4, pp. 17-23, July 1961

A study of the volt-ampere characteristics of the tunnel-diode pair, or twin circuit, which brings into focus the advantages of the circuit over the single tunnel diode, is presented. The V-I characteristic provides the designer with valuable information concerning the effects of varying the voltage of the sources supplying the bias voltage for the pair; the effects of internal resistance of the supply sources; the design of diode-pair circuits to perform majority logic; the design of diode-pair circuits for astable, monostable, and bistable multivibrator operation; the trigger requirements of multivibrator circuits; and the effects of loading upon multivibrator circuits.

12,064 THE DEVELOPMENT OF THE H-PARAMETER FORMULAE USING MATRICES by J. S. Bell; Electronic Engrg., Vol. 33, p. 386(L), June 1961

The use of matrix algebra to develop the h-parameter formulae of transistor networks is discussed. From a general matrix, which includes the effect of the load on the terminal voltages and currents, voltage gain, current gain, input impedance and output impedance can be computed easily.

12,065 BLOCK-DIAGRAM REPRESENTATION OF JUNCTION DIODES AND TRANSISTORS by G. Bruun (U. California); IRE Intl. Conv. Rec., Vol. 9, Part 3, pp. 10-25, Mar. 1961

A block-diagram description of junction diodes, diffusion transistors and drift transistors under large-signal operating conditions is presented. This description of the devices facilitates the connection between the physics and the nonlinear circuitry of the devices; a better understanding of the nonlinear operation of more complicated devices such as mesa transistors is also facilitated. The block diagrams are of a simple type, as they are made up of nonlinear time-independent blocks and of linear operator blocks. The diagrams assume that the diffusion equation is linear; this is not correct at large currents. The other nonlinearities in the devices as given from the Boltzmann equation are, however, so pronounced that they will be dominating even in many cases where the nonlinearity of the diffusion equation is significant. Nonlinear HF circuit problems to which the block-diagram representation has proven useful are switching, almost linear amplifier (cross-talk interference) and class C amplifier problems.

12,066 THE CHARACTERISTIC PROPERTIES OF TRANSISTORS AND RELATIONS BETWEEN THEM FROM POINT OF VIEW OF TRANSMISSION ENGINEERING [in German] by W. Benz (Telefunken, Backnanz); Frequenztechnik, Vol. 15, pp. 17-29, Jan. 1961

The relations between dc voltages and dc currents and their temperature dependence are briefly considered. An equivalent circuit is derived from the physics of transistor action and the dependence of its elements on temperature and dc operation point are discussed. After some remarks concerning noise and nonlinear distortions the limits of operations are discussed, i.e. the maximum voltage and maximum junction temperatures. Finally the problems resulting from the application of the transistor as a switching device are shown.

12,067 CIRCUIT APPLICATIONS FOR NEGATIVE RESISTANCE SEMICONDUCTOR DEVICES by R. C. Ricci (MIT); U.S. Gov. Res. Rep., Vol. 36, p. 40(A), July 5, 1961
AD 255 840

The p-n-p-n Triode and the p-n-p-m thyristor are analyzed and the temperature variation of the V-I characteristic and the capacity of the devices as a function of dc bias are investigated. Negative resistance devices are simulated using transistor pairs of opposite polarity types. The negative resistance semiconductor triodes examined are the RCA germanium thyristor, TA1832, and the GE high power silicon p-n-p-n triode, ZJ39A. Circuits utilizing the properties of the triode and the

thyristor have been designed, built, analyzed, and evaluated. These circuits include a free-running pulse generator, a triggered pulse generator, a saw-tooth generator, a two thyristor flip-flop, and a one thyristor flip-flop. A monostable, astable, and bistable operation of circuits is also discussed.

Protection of Junction Transistors in Power Generating and Charging Equipment - See 11,978

AMPLIFIERS

12,068 GAIN CONTROL FOR TRANSISTOR DETECTOR OR AMPLIFIER by W. F. Barlow (Amalgamated Wireless Valve); U.S. Pat. 2,997,656, Issued Aug. 22, 1961

A single gain control with reduced distortion is described. A potentiometer is connected from the collector through a capacitor to the emitter, with the wiper arm returned to the supply source. The collector is connected to the supply through an inductor. Variation of the wiper arm introduces degeneration into the emitter circuit and shunts the collector load to obtain gain control. In a detector, the gain control provides either a voltage increasing with carrier level at the emitter, or decreasing at the collector. AGC voltages may be taken from either electrode.

12,069 NOISE MODULATION EFFECTS IN TRANSISTOR RECEIVERS by W. A. Rheinfelder (Motorola); Solid State J., Vol. 2, pp. 25-28, July 1961

Noise modulation in transistor receivers is discussed. It is shown to be due to cross-modulation caused by third order nonlinearities, and intermodulation due to second order nonlinearities. Suggested methods for reduction of cross-modulation include: increase of selectivity ahead of the nonlinear elements, keeping the use of the RF stage low, correct choice of bias point (this results also in lower intermodulation), and use of feedback to reduce nonlinearities.

12,070 LOW-NOISE AMPLIFIERS FOR CENTIMETER AND SHORTER WAVELENGTHS by G. Wade (Raytheon); Proc. IRE, Vol. 49, Part 1, pp. 880-891, May 1961

Techniques for the low noise detection of centimeter signals are discussed. The low-noise devices which are currently competitive or which show future promise include traveling-wave tubes, parametric amplifiers, tunnel diodes, masers, photon counters, and photosensitive detectors. Low noise has been attained in parametric devices using both electron beams and semiconductor diodes. Some of the lowest noise temperatures measured on any unrefrigerated microwave amplifiers are those for electron-beam parametric amplifiers. Refrigerated semiconductor-diode parametric amplifiers have given lower noise temperatures. The tunnel-diode amplifier is the most recent negative resistance microwave device. It seems to have limitations as far as extremely low-noise performance is concerned, but nevertheless it is a good competitor for many low-noise applications. So far, the maser is the best in microwave low-noise amplification. Intrinsic maser noise temperatures of a few degrees are readily attainable. Photon counters and photosensitive detectors are inherently even quieter and give promise of considerable future potential.

12,071 HIGH-IMPEDANCE DRIVE FOR THE ELIMINATION OF CROSSOVER DISTORTION by J. J. Faran, Jr. and R. G. Fulks (Genl. Radio); Solid State J., Vol. 2, pp. 36-40, Aug. 1961

The elimination of crossover distortion in Class B amplifiers by driving the output stage from a high-impedance source is discussed. Bias networks with their attendant thermal problems are unnecessary since the thermal stability of amplifiers of this type can be excellent. Other advantages of this mode of operation are discussed, and some circuit arrangement are suggested.

12,072 COMMON-EMITTER AMPLIFIER by R. Leek (Loughborough Coll. Tech.); Electronic Tech., Vol. 38, No. 8, pp. 285-297, Aug. 1961

The optimum design of a common-emitter amplifier is discussed. The conditions under which a simple equivalent circuit for a transistor may be applied with accuracy to an analysis of the common-emitter amplifier are examined. Theoretical results of the voltage gain-frequency relationship are shown to agree with experiments. Formulae are derived in terms of circuit parameters which indicate the amount of emitter feedback resistance required to provide the maximum bandwidth at any specified zero-frequency voltage gain. It is shown that the theory for the isolated amplifier stage may be applied to amplifiers having cascaded common-emitter stages.

12,073 MEANS FOR COMPENSATING ELECTRIC CIRCUIT ARRANGEMENTS IN RELATION TO EXTERNAL CONDITIONS by E. Wolfendale (N. A. Philips); U.S. Pat. 2,991,424, Issued July 4, 1961

A technique for stabilizing a single junction dc transistor amplifier or a cascade of junction transistor amplifiers against temperature variations is described. In the case of a grounded emitter amplifier, a second compensating grounded emitter amplifier is connected to the first amplifier so that a fraction of the temperature-dependent collector current of the compensating transistor flows in the base of the compensated transistor. This current opposes the temperature-dependent cutoff current of the compensated transistor and stabilizes the amplifier. The base of the compensating transistor is open-circuited. A multistage dc amplifier can be stabilized by connecting a compensating transistor to the first stage of the amplifier. A circuit in which the compensating transistor supplies the whole base current of the compensated transistor and a circuit for stabilizing a grounded base amplifier are also described.

12,074 ZENER DIODE CIRCUITS FOR STABLE TRANSISTOR BIASING by J. Kabell and V. H. Grinich (Fairchild); Semicon. Prod., Vol. 4, pp. 43-48, May 1961

The stabilization of the dc operating point of transistor amplifiers by the use of Zener diodes is discussed. The circuit using the Zener diode has a high degree of stability with a minimum drain of power from a single simple power supply. The operating point of the transistor is established in a more stable manner than in commonly used bias circuit arrangements because it is much less affected by variations of temperature and variations among transistors. Design methods and experimental results with germanium and silicon units are given for the Zener diode scheme and compared to conventional methods of biasing.

12,075 HYBRID DC DESIGNING AMPLIFIERS TO WITHSTAND MISSILE ENVIRONMENTS by R. L. Konigsberg (Johns Hopkins U.); Electronics, Vol. 34, pp. 157-159, Aug. 11, 1961

A transistorized hybrid dc operational amplifier which operates

to 100°C and has short circuit stability (in the Nyquist sense) is described. The dc gain is 9×10^5; input impedance is 230 kohm and the output impedance is 1 kohm. The equivalent input misalignment voltage and current generators are less than 1 mv and 1 μa respectively. The equivalent input circuit for the main amplifier, with its equivalent input voltage and current dc misalignment generators, is developed. The circuit consists of a main dc amplifier, a chopper amplifier used for drift correction in the Goldberg arrangement and a LF ripple filter. A vacuum tube input stage is used with grid and leakage currents below 10^{-9}amp. The amplifier gain crossover frequency was between 40-65 kc for several tested, with a phase margin of 50-60°.

12,076 ELECTRONIC DETERMINATION OF THE I, G, AND I/G PARAMETERS OF A TUNNEL DIODE by C. R. Gneiting (Johns Hopkins U.); Rev. Sci. Instr., Vol. 32, pp. 907-908, Aug. 1961

A method of obtaining certain necessary values in the design of a minimum noise figure tunnel diode RF amplifier is described. The point of minimum $I/|G_a|$ ratio, the diode bias current required at this point, and the conductance obtained at this point are considered. A scheme whereby X-Y recordings of the I-V, G-V, and I/G-V curves for a tunnel diode can be obtained is described.

12,077 A MILLIMETER-WAVE ESAKI DIODE AMPLIFIER by C. A. Burrus and R. Trambarulo (Bell Labs.); Proc. IRE, Vol. 49, pp. 1075-1076(L), June 1961

An amplifier comprising "formed" point-contact Esaki diodes of n-type GaAs, mounted in a reduced-height rectangular waveguide having a LF cutoff of 48 kMc, is described. The frequency of operation is determined largely by the length and shape of the zinc contact and by the conditions under which the diode was formed. Oscillations are suppressed by the positioning of a contacting piston which also tunes the amplifier frequency. Stable gains up to 35 db were attained with gain compression appearing at a power output of about 0.3 μw. The bandwidth is about 40 Mc at a peak gain of 20 db. The highest frequency at which amplification is observed is 85.5 kMc. Near 55 kMc the noise figure is found to range between 16 to 18 db.

12,078 DEVICE BASED ON GaSb, Electronic News, pp. 1-2, June 19, 1961

A UHF and L-band amplifier consisting of a GaSb diode amplifier module, two circulators, and a power supply is announced. The device offers the advantages of small size as compared to masers and paramagnetic amplifiers, elimination of high frequency pumping circuits and low power requirements of a few mw. Noise levels of 2.5-3.5 db are realized through the use of a GaSb tunnel diode. Typical characteristics of the diode are 20:1 peak-to-valley ratios, 2-4 kMc cutoff frequencies and 1-3 ma peak currents. 1000 hr life at 5 times the peak current show no deterioration in electrical characteristics.

12,079 EMITTER PEAKING IMPROVES VIDEO AMPLIFIER RESPONSE by J. B. Fisher (RCA); Electronics, Vol. 34, pp. 94-95, May 19, 1961

An analysis based on the familiar hybrid-pi equivalent network of a grounded emitter transistor pulse amplifier is presented to show the advantages of emitter peaking in a video amplifier circuit. The analysis consists of the calculation of an equivalent input network, the calculation of an output network and the combination of these two calculations to provide useful design equations. Emitter peaking improves the response, linearity, and stability of a transistor video amplifier as well as minimizing the effects of varying transistor internal parameters. An example of pulse amplifier design procedure is also given.

12,080 HIGHLY LINEAR AMPLIFICATION WITH TRANSISTORS by N. E. Chasek (Bell Labs.); IRE Trans., Vol. ED-8, No. 2, pp. 110-115, Mar. 1961

Highly linear amplifiers using HF diffused base transistors in common base configurations are discussed. Experimental results optimum operation circuit constants and a general analytical method for treating these amplifiers are presented. An extensive analysis of the nature and source of nonlinearity in transistor amplifier circuits is included. An experimental amplifier using push-pull 2N509 or 2N1195 transistors provided 13 db gain with signal-to-distortion ratios of 70-80 db for broadband white noise signals with +3 dbm of average output power or sine wave signals with ±15 dbm peak output power.

12,081 A DOUBLE-DELAY-LINE CLIPPED LINEAR AMPLIFIER by R. L. Chase and V. Svelto (Brookhaven Natl. Lab.); IRE Intl. Conv. Rec., Vol. 9, Part 9, pp. 106-111, Mar. 1961

A compact transistorized linear amplifier suitable for many radiation counting applications is described. The amplifier delivers symmetrical double-delay-line differentiated output pulses, up to ±10v in amplitude with a differential nonlinearity of ±1 per cent. It tolerates input signals 400 times full scale without producing spurious output pulses. Either a prompt output or one delayed by 2 μsec is available. The clipping lines and the signal delay line are all terminated at both ends so that physically small, relatively imperfect delay lines can be employed. Five amplifiers occupy only 12-1/4 in. in a standard 19-in relay rack.

12,082 DETERMINING PHASE SHIFT AND GAIN OF SUBAUDIO DIFFERENTIAL AMPLIFIERS by W. C. Acha (Hughes Aircraft); Electronics, Vol. 34, pp. 52-55, June 2, 1961

An instrument which measures the voltage null ratio and the phase shift of a differential amplifier at subaudio frequencies is described. One reference signal, V_1, has a constant voltage and adjustable phase with respect to the other reference signal V_2. V_2 has an adjustable voltage but constant phase with respect to V_1. V_2 is used as the input to the tested differential amplifier, whose output is compared with V_1 through a summing network. By alternately adjusting the phase of V_1 and the voltage of V_2 until a null is produced, the voltage null ratio and the phase shift of the amplifier are determined.

12,083 VOLTAGE SIGNAL COMPARISON MEANS WITH STORAGE MEANS by T. J. Blocher, Jr. (Westinghouse Air Brake); U.S. Pat. 2,991,372, Issued July 4, 1961

A differential amplifier for comparing the amplitudes of two input signals is described. The inputs are of the same polarity, but need not attain their maximum amplitude simultaneously. The input signals are integrated and selectively gated to appear across the primary windings of an iron core transformer. The amplitude of the output signal from the secondary winding is proportional to the difference in amplitude of the two input signals. Loading of the input signals is prevented by diode biasing.

12,084 THE DESIGN OF LOW NOISE, HIGH INPUT IMPEDANCE AMPLIFIERS by L. Blaser (Fairchild); Solid State J., Vol. 2, pp. 21-24, July 1961

Basic requirements of transistors and associated circuitry for low noise-high impedance amplifier design are briefly summarized. The calculated and measured noise figures of a transistor operated from a high impedance source are compared. Characterization of noise properties of a transistor is given, with the 2N1711 transistor noise properties as an example. Design examples of high impedance amplifiers are also given.

12,085 A SELECTIVE RC AMPLIFIER USING TRANSISTORS by J. J. Sparkes (Brit. Telecommun. Res.); Electronic Engrg., Vol. 33, pp. 387(L), June 1961

A modified dual of a Wien bridge arm, which can be used in a transistor selective amplifier, is described. This modified dual network may be derived by interchanging two parameters in the [A] matrix of the Wien bridge arm, provided certain approximations are made.

12,086 BANDPASS TRANSISTOR AMPLIFIERS by C. J. McCluskey (Philips Electronics Ind. Ltd., Toronto); Electronic Tech., Vol. 38, pp. 183-186, May 1961

A determinant method for the analysis of the amplitude and phase responses of tuned amplifiers using transistors with complex internal feedback coupled by four- or two-terminal filter networks is discussed. Correction terms for a practical tuning procedure are presented. The form is well suited to the analysis of multistage bandpass amplifiers.

12,087 POLARITY SENSING AMPLIFIER CIRCUIT by V. T. Carbone and R. D. Clark, Jr. (Westinghouse); U. S. Pat. 2,985,774, Issued May 23, 1961

A transistorized, static, bidirectional amplifier circuit capable of detecting and magnifying an error signal is described. The amplifier employs two flip-flop circuits that are coupled for push-pull operation; the polarity of the input signal effects saturation in the appropriate flip-flop and energizes an indicating relay. The circuit may be employed as a sensing amplifier in tracking for automatic motor control systems.

12,088 AN ENGINEERING APPROACH TO THE DESIGN OF TRANSISTOR FEEDBACK AMPLIFIERS by E. M. Cherry (U. Melbourne); Proc. IRE Austl., Vol. 22, pp. 303-320, May 1961

A technique for the design of transistor feedback amplifiers is developed based on the use of impedance mismatches between stages. Expressions are derived from the transmittance of the four basic building blocks (the series and shunt single stage feedback amplifiers and the current and voltage feedback pairs) and methods of interconnection which achieve the mismatch are considered. The expressions for the transmittance are both simple and highly accurate, yet they involve no quantitative information about the transistors at all. It is concluded that transistor circuitry is far more designable than vacuum tube circuitry. Three examples in the use of the design philosophy are given, covering the audio and video frequency ranges up to 20 Mc.

Parametric Amplifiers Using Varactors - See 11,952 and 11,954

12,089 A SOLID-STATE ANALOG TO A TRAVELLING-WAVE AMPLIFIER by H. Heilmeier (Princeton U.); Proc. IRE, Vol. 49, pp. 1079-1080(L), June 1961

An L-band nondegenerate parametric amplifier using a shielded helix as the propagating circuit and three parallel stacks of varactor diodes as the active medium is described. Each stack contains 8 pill varactor diodes placed end to end and is mounted symmetrically in the helix. Gains of 4 to 8 db with bandwidths of 15 to 25 per cent were obtained at L band with a pump frequency of 2020 Mc. A noise figure of 9.8 db was measured. The diodes have to be selected to ensure the proper operating point and must be carefully positioned in the helix to achieve the proper interaction impedance.

12,090 RESEARCH AND DEVELOPMENT ON SEMICONDUCTOR PARAMETRIC AMPLIFIERS by K. K. N. Chang, H. J. Prager and others (David Sarnoff Res. Ctr.); U.S. Gov. Res. Rep., Vol. 35, p. 570(A), May 16, 1961 PB 153 268

The expressions for gain, bandwidth and noise factor of tunnel diode amplifiers are shown to be analogous to those found for a cavity-type parametric amplifier with one striking difference; the bandwidth of the tunnel diode amplifier is comparatively broad. The noise in the tunnel diode was found to be essentially of the shot-effect type. When the tunnel diode amplifier operates at infinite gain, oscillation takes place. A simple theory for a tunnel diode oscillator is derived. In addition to amplifiers and oscillators, tunnel diodes can be used as frequency converters. The unusual I-V characteristic of tunnel diodes suggested a down converter which can exhibit both conversion gain and low noise factor. Parametric and tunnel diodes are both two-terminal devices. To achieve four-terminal amplifiers with these devices, a traveling-wave scheme using a series of distributed diodes has been suggested.

Laser Amplifiers - See 12,041

12,091 SEMICONDUCTOR DIODE CIRCUIT PROVIDES GAIN by S. Ritterman (Picatinny Arsenal); Electronics, Vol. 34, pp. 60-62, June 2, 1961

The application of diodes in amplifying circuits, using the forward and reverse diode states, is discussed. When a forward biased semiconductor diode is suddenly biased in the reverse direction, the carriers in the diode permit a reverse transient current to flow until steady-state conditions have been established. By controlling this phenomenon with an input signal, amplification is achieved. Both the input signal and the power supply for the diode amplifier are half-wave rectified voltage. The frequency of the former should be equal to or lower than that of the latter. Typical experimental results are: input signal frequency 100 cps, power supply frequency 0.5 Mc, gain 1.5; and input signal frequency 1 kc, power supply frequency 50 kc, gain 4.

Tunnel Diode Amplifiers - See 12,077

12,092 A MATCHED AMPLIFIER USING TWO CASCADED ESAKI DIODES by D. R. Hamann (MIT); Proc. IRE, Vol. 49, Part 1, pp. 904-906, May 1961

A new type of circuit for matched amplification using negative resistance devices is described. This circuit consists of a quarter-wave transmission line section whose input and output are paralleled by negative conductances. The characteristics of such an amplifier are discussed and an expression for its noise figure is derived. The development of a 30 Mc amplifier

using two Esaki diodes is described. Experimental results are presented, including curves of the characteristics as a function of frequency. A gain of 8.9 db was measured with a noise figure of 4.3 db.

12,093 A QUICK METHOD FOR CALCULATING TRANSISTOR AMPLIFIER CIRCUITS by R. R. Vierhout and A. J. H. Vendrik (R.C.U., Netherlands); Electronic Engrg., Vol. 33, pp. 375-381, June 1961

Calculations of transistor circuit performance based on four-pole theory are presented. If the hybrid parameter h_{12} is neglected, as may be done for calculations in practice, the transistor can be treated as a current amplifier in a way analogous to the tube as a voltage amplifier. A useful quantity is the transfer impedance with which many characteristics of the circuits with feedback can be easily calculated. It is shown that an input impedance of several megohms is attainable with a special type of feedback. Various ways of improving the temperature stability of transistor circuits are discussed. Formulae for noise in transistor circuits are derived.

Superconductor Amplifiers - See 12,048

12,094 TRANSISTOR AMPLIFIER by D. Eklöv (Svenska Relafabriken); U.S. Pat. 2,985,842, Issued May 23, 1961

A two stage temperature stabilized transistor amplifier suitable for use in loud-speaking systems as a pre-amplifier is discussed. Compensation is provided by resistance networks in the emitter and base circuits of the amplifier.

12,095 POWER AMPLIFIERS by G. C. Sziklai and R. D. Lohman (RCA); U.S. Pat. 2,985,841, Issued May 23, 1961

A transistor power amplifier capable of supplying pulsed or bidirectional waveforms to a low impedance load and of functioning as a S.P.D.T. switch is described. A common output impedance is shared by the emitter circuit of the first transistor stage and the collector circuit of the second; with suitable bias, the circuit may be balanced to provide zero load current in the absence of input, providing an amplified, bidirectional output free of any dc components. Biasing the first stage into conduction and the second stage into cutoff provides an operation analogous to a S.P.D.T. switch.

12,096 POSITIVE AND NEGATIVE FEEDBACK MULTIPLY AMPLIFIER INPUT IMPEDANCE by R. L. Willett (Martin); Electronics, Vol. 34, pp. 52-53, July 7, 1961

The use of positive and negative feedback to alter the input parameter of a device, resulting in a stable amplifier with an input conductance adjustable to zero at almost any output load, is described. This impedance multiplier provides an output of 10 v peak-to-peak and 1 ma with a noise figure of 15 db and a total dynamic range of about 132 db. Being insensitive to changes in temperature, supply voltage or transistor parameters, the multiplier circuit has an input conductance of zero, voltage gain of unity and excellent linearity. The schematic of the circuit is shown together with detailed explanations of its operation. Included also are the equations giving the input resistance with large values of positive feedback, the approximate gain equation for the positive feedback loop and its feedback ratio in terms of the circuit and transistor parameters.

12,097 EXACT CALCULATIONS FOR CLASS A AND B TRANSFORMER COUPLED AMPLIFIERS by J. S. MacDougall (Raytheon); Semicon. Prod., Vol. 4, pp. 37-43, May 1961

Power transistor circuits operated under large signal conditions are limited in their power output capabilities by the "saturation resistance" and the supply voltage. Formulae derived to include this information allow exact calculation of Class A and B stage operating conditions and eliminate entirely the guesswork involved in Class A design. Simple design procedures are detailed for Class A and B designs which allow very good prediction of circuit performance.

OSCILLATORS

12,098 OSCILLATOR AMPLITUDE CONTROL by E. K. Van Tassel and R. E. Yaeger (Bell Labs.); U.S. Pat. 2,992,399, Issued July 11, 1961

Transistor feedback oscillators for use in transistorized carrier telephone transmission systems are described. The oscillators utilize a series-connected capacitor and avalanche breakdown junction diode across the output to achieve equal positive and negative peak amplitudes and a feedback loop gain of unity. Positive oscillations are limited by the forward characteristics of the diode and the negative oscillations are limited by avalanche breakdown. The avalanche breakdown voltage is selected to be twice the limiting peak amplitude.

12,099 HIGH STABILITY TRANSISTOR OSCILLATOR by D. M. Chauvin (Westinghouse); U.S. Pat. 2,985,847, Issued May 23, 1961

A transistor oscillator having high frequency stability is described. Feedback coils, employed in the base and collector circuits, resonate above the $f_{\alpha co}$ of the transistor and provide increased frequency stability. The circuit is similar to that of a Meissner vacuum tube oscillator.

12,100 TRANSISTOR OSCILLATOR by D. W. Dodge (GM); U.S. Pat. 2,983,879, Issued May 9, 1961

A transistor oscillator which features frequency stability in spite of changes in supply voltage and in interelectrode capacitance from transistor to transistor is described. The operating frequency of the oscillator is determined by a resonant circuit in the output circuit of the oscillator. As the voltage applied to the collector electrode increases, the interelectrode capacitance between the collector and emitter electrodes varies in such a manner that the resonant frequency is increased. The voltage applied to the base electrode also increases and changes the value of the base-emitter interelectrode capacitance in such a manner that the resonant frequency decreases. The two changes cancel each other and frequency changes are minimized. The reverse effects occur when the supply voltage decreases. Variations in frequency because of variations in interelectrode capacitance from transistor to transistor are minimized by means of a capacitor connected in series with the interelectrode capacitance.

Oscillators for Electronic Organs - See 12,161

12,101 TRANSISTOR RELAXATION OSCILLATOR by K. H. Schmidt (Mosler Res.); U.S. Pat. 2,988,708, June 13, 1961

A two transistor relaxation oscillator utilizing complementary

symmetry is described. The circuit is shown incorporated in various warning systems, eliminating the need for relays and make-and-break contacts usually employed.

12,102 VOLTAGE-VARIABLE CAPACITORS MAKE A RELAXATION OSCILLATOR by J. Sopez, S. J. Brown and J. Brown (St. Louis U.); Electronics, Vol. 34, pp. 96-98, May 19, 1961

Use of a varactor diode in a series resonant circuit to give output voltages of two levels is described. The resonant circuit consists of an inductance, a variable capacitance diode and a RC tank in series. The input is an RF voltage source. As the voltage across the RC tank, which provides the backward bias to the diode, decreases exponentially because of dc loss in the tank, the value of the capacitance of the diode changes correspondingly. At a certain point, series resonance occurs and there is a sudden jump in the voltage across the RC tank. Two such series resonant circuits are connected in parallel to form a relaxation oscillator with a controllable frequency range between 15 cps to 1.5 kc.

12,103 MONOSTABLE MULTIVIBRATOR WITH EMITTER-FOLLOWER FEEDBACK TRANSISTOR AND ISOLATED CHARGING CAPACITOR by R. E. Milford (GE); U. S. Pat. 2,987,632, Issued June 6, 1961

A monostable multivibrator employing three transistors is described. Two of the transistors are cross coupled to each other, while the third, in the grounded collector configuration, is connected between the base of the normally highly conducting second transistor and one side of the timing capacitor. This assures that the charge stored by the timing capacitor during the stable state is determined by the supply voltage and is relatively independent of transistor parameters and, consequently, temperature variations. Thus a constant unstable state duration is achieved, while allowing a wide range of duty cycles by varying the trigger signal recurrence rate. In a typical circuit, the duty cycle (per cent of time in unstable state) ranged from 63 per cent to 93 per cent for a constant temperature, while a temperature change from 35° to 65°C varied the duty cycle by less than 0.1 per cent.

2,104 SYNCHRONIZED BLOCKING OSCILLATOR by G. W. Applegate (Secretary of the Army); U.S. Pat. 2,985,846, Issued May 23, 1961

A high frequency synchronized, transistor blocking oscillator with improved triggering action and repetition frequency is described. A conventional R-C network in the emitter circuit establishes the cutoff interval and maintains the frequency of the blocking oscillator. An L-C tank is employed in the collector circuit to provide oscillations higher than those of the blocking oscillator. Such a circuit gives high frequency oscillations of 1 Mc and blocking oscillations of 4,500 cycles.

Parametric Tunnel Diode Oscillators - See 12,090

Maser Oscillators - See 12,022

2,105 VANE CONTROLLED TRANSISTOR OSCILLATOR by J. G. Raffaelli (Genl. Controls); U.S. Pat. 2,985,848, Issued May 23, 1961

A transistor oscillator in which oscillations are controlled by the vane of a D'Arsenval type movement, such as a millivoltmeter or pyrometer, is described. An aluminum vane is interposed between two inductively coupled coils of the transistor oscillator; movement of the vane either enhances or suppresses oscillations in the circuit. Particular circuit cited is employed to open and close a relay by vane movements.

SWITCHING CIRCUITS

12,106 MATHEMATICAL CIRCUIT ANALYSIS AND DESIGN by A. Brown, L. R. Hulls et al. (Sperry Rand); U.S. Gov. Res. Rep., Vol. 36, p. 37(A), Sept. 20, 1961 AD 259 786

Mathematical techniques are applied to the analysis of the steady-state performance of a transistor gate-inverter circuit. The statistical calculation of circuit behavior is discussed and results are presented for the computer analysis of a typical circuit. A detailed mathematical description of the technique for determining the maximum component tolerance is included and the subsequent statistical study indicates the importance of the maximum tolerance determination in circuit design.

12,107 TRANSIENT RESPONSE OF GROUNDED EMITTER SWITCHING CIRCUITS by S. C. Chao (Genl. Precision Lab.); Semicon. Prod., Vol. 4, pp. 27-33, May 1961

The transient response of a non-saturating grounded emitter switch is analyzed. The effect of collector capacitance and load resistance is taken into effect. The turn-on delay and rise time are derived assuming a ramp input voltage which is closer to the practical case than the step input normally assumed. The turn-off transient response is derived by plotting a transcendental equation. The accuracy of this analysis has been verified by experimental observations using alloy junction transistors. The results obtained may be used by circuit designers to understand and predict the response time of transistor switching circuits.

12,108 THEORY OF TEM DIODE SWITCHING by R. V. Garver (Diamond Ord. Fuze Labs.); IRE Trans., Vol. MTT-9, pp. 224-238, May 1961

The theory of TEM diode switching and the design of TEM microwave diode switches are discussed. A few experimental results are reported for the purpose of supporting the theory and demonstrating the exceptional bandwidth possible. The switching action of one of two or more diodes and the biasing of the center conductor of a TEM transmission line over broad-frequency bandwidths without interacting with the RF signal are analyzed. The use of point-contact Ge, varactor and gold-bonded Ge diodes for TEM switching is discussed. Some considerations of switching speed and maximum power-handling capacity are given. A coaxial transmission line switch in which two gold-bonded diodes provide 26 db or greater isolations and insertion loss ranging from 1.6 db to less than 1 db from 40 - 4000 Mc has been constructed. The addition of a bias lead should increase the insertion loss 0.4 db or less over the 100-to-1 bandwidth, the maximum increase being at the upper and lower bounds.

12,109 HIGH SPEED SWITCHING CIRCUIT by T. Hamburger and C. H. Wood, Jr. (Westinghouse); U.S. Pat. 2,997,606, Issued Aug. 22, 1961

A switching circuit which minimizes the effect of circuit capacitance on the output pulse trailing edge is described. A negative input pulse is applied to a normally off p-n-p

transistor and through a differentiating circuit to a normally off n-p-n transistor. The trailing edge of the pulse switches the n-p-n transistor on, providing a low impedance discharge path for the circuit capacitance.

12,110 SEMICONDUCTOR TRIGGER CIRCUIT by W. B. Cagle (Bell Labs.); U.S. Pat. 2,982,869, Issued May 2, 1961

An improved bistable multivibrator which utilizes conditional steering is described. In this mode of operation, actuation of the steering gates is conditioned upon a change of the flip-flop states and removal of the triggering pulse. This pulse may be of any length without consequent oscillation in the flip-flop operation, thus obviating the need for input waveform and control circuitry. Simplicity and economy are achieved by the use of slow reverse-recovery diodes. The latter also place limitations on the maximum frequency of the multivibrator.

12,111 TRIGGER CIRCUIT COMPRISING TRANSISTORS by E. Wolfendale (Philips); U.S. Pat. 2,986,650, Issued May 30, 1961

A trigger circuit consisting of a grounded base amplifier and a grounded collector amplifier connected by a feedback loop is described. Both transistors are p-n-p junction type. When the grounded base amplifier is conducting, the grounded collector amplifier conducts only very slightly and is stable due to a very high input resistance. When the grounded collector amplifier is conducting, its emitter current is greater than the emitter current of the grounded base amplifier. This difference in current causes the emitter of the grounded base transistor to be negative with respect to the base and the transistor shuts off. When the grounded base amplifier is conducting, it can be cut off by the application of a negative pulse to any point in the feedback loop or by a positive pulse to the base of the transistor. When this transistor is cut off, it can be made conductive by applying a positive pulse to a point of the feedback loop or by applying a negative pulse to the base of the cutoff transistor.

12,112 BISTABLE TRIGGER CIRCUIT by G. F. Abbott, Jr. and E. E. Sumner (Bell Labs.); U.S. Pat. 2,987,628, Issued June 6, 1961

A low cost, fast operating bistable transistor trigger circuit which handles high currents without excessive dissipation is described. The high speed of point contact transistors and the high current handling capability of junction transistors are utilized in this circuit by employing a junction transistor in the grounded-emitter configuration as the switching element or buffer stage for a point contact transistor bistable stage. Excessive dissipation is avoided when large currents are handled by supplying the output through the low emitter-to-collector impedance of the junction transistor.

12,113 FAST RESPONSE GATING CIRCUIT by F. E. Blount (Bell Labs.); U.S. Pat. 2,985,769, Issued May 23, 1961

A fast response, bistable, transistor pulse amplifier with high-current handling capacity is described. The amplifier employs a point contact transistor and a junction transistor; the point contact provides the bistability and rapid switching, and the junction transistor provides for high-current capacity. Another junction transistor is employed in an enabling circuit which turns the amplifier on or off. Switching from 120 ma to 0 ma in less than 1 μsec is cited.

12,114 TRANSISTORIZED GATING CIRCUIT by P. Emile, Jr. (U.S. Army); U.S. Pat. 2,982,868, Issued May 2, 1961

An improved transistorized gating circuit employing dc coupling is described. The circuit passes an input signal without distortion when a relatively low-level gating pulse is applied and produces no significant shift of the dc level at the circuit output. Two transistors are utilized, the first being employed as a gating switch in combination with a "T" network, the second as a common-emitter amplifier. The design takes advantage of the fact that a saturated transistor acts as a very low impedance for both positive and negative voltages applied between its collector and emitter terminals. An over-all gain of 0.75 is given for a specific circuit.

12,115 PASSIVE SIGNAL GATING CIRCUIT by R. E. Gottfried (Thompson RW); U.S. Pat. 2,994,789, Issued Aug. 1, 1961

A gating circuit that employs a control signal whose voltage is significantly smaller than the signal voltage to be gated is described. A high current ratio is maintained between the currents flowing in the circuit due to the control and applied signals. Effective passage of applied pulse E_s to the output terminal is dependent upon continued conduction of a series diode. This requisite can be met by making $E_1/R_1 > E_s/R_L$, where E_1 is the control gate, R_1 is the effective control circuit resistance and R_L is the load resistance. Thus in the ON condition a large control gate current flows through a series diode. Application of a signal pulse voltage E_s produces a signal current which reduces but does not eliminate the gate current. Signals will be passed with substantially no attenuation. In the OFF condition the series diode is rendered non-conductive and a shunt diode is made conductive resulting in high attenuation (60 db) of the input signal. A practical circuit is given in which a 6 v gate pulse is employed to control a 50 v signal pulse.

12,116 MAGNETIC GATES AND BUFFERS by T. H. Bonn (Sperry Rand); U.S. Pat. 2,987,708, Issued June 6, 1961

Magnetic gate and buffer circuits suitable for use in connection with computing and data translating systems are described. The basic circuit comprises a core with two windings. One winding is fed by spaced pulses and has its output terminating in a load. The other coil controls the impedance of the first coil by means of any one of several devices which are employed to vary the impedance across the second coil. In the magnetic gate, there are several cores, one for each input. Each core has a power and a control winding. The power windings are connected in series with the pulse source and the load, and each control winding is shunted by its input switch such as a transistor, gas tube, etc. If any of the switches remain open, the power winding controlled by that switch will have high impedance and little current will flow into the load. Several modifications and embodiments of the basic circuit are given.

12,117 AMPLITUDE DISCRIMINATING SYSTEM by G. W. Floyd (Hughes Aircraft); U.S. Pat. 2,992,340, Issued July 11, 1961

The development of an amplitude discriminator to detect signals derived from magnetic tapes or magnetic drums is described. The signal derived from the magnetic head is amplified, full-wave rectified, and then applied to the control electrode of a normally conducting transistor in a monostable circuit. When this rectified signal exceeds a certain predesignated level, the normally conducting transistor will be cut off, a normally cutoff transistor will conduct, and an output signal will be

generated correspondingly. Otherwise there is no change of state of the monostable circuit.

12,118 BILATERAL SWITCHING USING NONSYMMETRIC ELEMENTS by M. Aoki and G. Estrin (U. California); U. S. Gov. Res. Rep., Vol. 35, p. 719(A), June 16, 1961 PB 149 816

A magnetic core configuration which has been investigated and applied in a word organized memory is described. It consists of a pair of mutually inverted and parallel connected transistors, which are not generally symmetrical. Some of the system considerations which determine the important design parameters are discussed. Methods for location of regions of satisfactory operation in the many-variable space of the inverted transistor pair are described.

Bilateral Switching Circuits - See 12,169

12,119 VARIABLE CONDUCTANCE SAMPLING SWITCH by J. E. Taylor (GE Res. Labs.); Rev. Sci. Instr., Vol. 32, pp. 754-755(L), June 1961

A semiconductor sampling switch which forms weighted sums of discrete samples of a continuous voltage waveform is discussed. Weighting factors which multiply the various samples vary with the switch conductance. The circuit consists of a diode bridge and a blocking oscillator. The voltage to be sampled is connected to the output for the duration of the pulse from the blocking oscillator. The forward conductance of the bridge can be changed by application of a voltage in series with the blocking oscillator output. The sampling switch has been operated both randomly and cyclically at rates from 20 to 50,000 samples/sec. The circuit was constructed to operate as an averaging memory with a variable decay rate and finds application in some control systems, i.e., for adaptive filters for recurrent signals in random noise.

12,120 SEMI-CONDUCTOR DIODE WAVEGUIDE SWITCH by T. H. B. Baker (Assoc. Elect. Ind. Res. Lab.); Electronic Tech., Vol. 38, No. 8, pp. 300-304, Aug. 1961

The theory of operation of a waveguide switch, relating the switching ratio, bandwidth and power handling capabilities to diode and transmission-line parameters, is given. The construction and performance of practical devices are described with particular reference to a p-i-n junction diode. The performance is illustrated by the results of tests made at high RF power levels, the transient response and the noise performance.

12,121 DIODE RING CIRCUIT by P. M. Thompson (Canadian Min. Def.); U.S. Pat. 2,923,894, Issued Feb. 2, 1960

An improved diode ring circuit which employs reverse connected avalanche mode operated diodes is described. One avalanche mode diode is placed in series with one forward mode diode in each arm of the ring. This prevents the non-conducting diodes of the ring from being switched on due to voltage reflected back from the load into the ring circuit. In prior circuits the output was restricted to current only. The forward mode diodes are chosen to have much higher avalanche breakdown voltages than the avalanche mode diodes. The circuit can be used as a switch controlling signal polarity, as a phase sensitive rectifier, or as a suppressed carrier modulator.

Computer Switching Circuits - See 12,173

Transistor Switching Circuits - See 12,066

12,122 SWITCHING CIRCUIT COMPRISING TEMPERATURE CONTROLLED SEMICONDUCTIVE DEVICE by M. C. Steele (RCA); U.S. Pat. 2,980,808, Issued Apr. 18, 1961

A switching circuit which utilizes impact ionization in a semiconductor at low temperatures is described. A variable resistance device such as a transistor or a photocell is connected in series with a voltage source, a load, and a semiconductor crystal. The crystal may be n- or p-type Ge, n- or p-type Si, p-type InSb, or an n- or p-type Si-Ge alloy and is cooled in a cryostat so that it exhibits a high resistance. Upon application to the variable resistance device of a signal which reduces the resistance of the device, the voltage across it decreases and the voltage across the crystal increases to that required to produce impact ionization. Impact ionization causes a sudden sharp increase in the current supplied to the load.

12,123 MAGNETIC GATE AND HEAD SWITCHING NETWORK EMPLOYING THE SAME by T. H. Bonn (Sperry Rand); U. S. Pat. 2,987,709, Issued June 6, 1961

Magnetic switching devices and magnetic switching systems incorporating such devices are discussed. The basic switching device consists of a core of magnetic material having a square hysteresis loop about which is wound two coils. One coil is connected in series with a diode and a load device and is driven by one source. The second coil is connected to another source of electrical energy. The sources are preferably, but not necessarily, unidirectional pulsating sources which produce positive pulses either in alternation or in synchronism, for example. The two coils are wound in opposite directions so when pulses are applied simultaneously to both coils the first coil appears as a low impedance, and substantially all the energy applied to the coil is transmitted to the load. If pulses are not applied simultaneously, most of the energy is absorbed in the core itself as the magnetic flux is appreciably changed and substantially none of the applied pulse reaches the load. A magnetic recorder head switching system incorporating the switching device is illustrated and discussed.

12,124 BISTABLE ELECTRICAL CIRCUIT by G. K. Groetzinger, P. Schwed and L. Witten (Martin); U.S. Pat. 2,980,807, Issued Apr. 18, 1961

A bistable wire-wound cryotron circuit is described. The cryotron is operated at a temperature at which it switches from one state to another when an applied magnetic field passes through a critical value H_c. When the applied field is less than H_c, the cryotron is switched to its superconducting state and when the applied field is greater than H_c, the cryotron is switched to its normal state. The applied field consists of two components, a constant magnetic field equal to or greater than H_c and a variable field in the opposite direction produced by current flowing in the cryotron control winding. The constant magnetic field H_a is used so that the two states will be self-sustaining and stable.

12,125 SWITCHING CIRCUIT by G. F. Pittman, Jr., R. O. Decker and C. I. Jones (Westinghouse); U.S. Pat. 2,985,772, Issued May 23, 1961

A transistorized, push-pull, high-efficiency switching circuit for high power and inductive applications is described. The circuit may be directly coupled to the input signal without employing coupling transformers and is equipped with commutating diodes which enable operation with inductive loads. Push-pull operation is attained by employing a load current

feedback circuit which switches bridging transistors "on" and "off". The circuit is well-suited to applications involving the control of exciter, generator, or motor fields.

12,126 POWER SWITCHING DEVICE by E. J. Martin and S. J. Gewirtz; U.S. Pat. 3,005,114, Issued Oct. 17, 1961

A four-stage power switching amplifier for heavy load currents is described. The first stage is connected as an emitter follower shunted by the transistor of the second stage; signal input to the first stage initially causes a light conduction and then causes avalanche breakdown, effecting heavy conduction in the emitter-collector circuit of the second stage. The third stage is a transistor switch which is responsive only to this heavy conduction; a low impedance clamp to ground is also connected into this stage to neutralize leakage current in the load until the switching arrangement responds to the heavy conduction. The fourth stage is isolated from the first three stages by properly biased diodes. The circuit has a turn "on" time of approximately 0.6 μsec and a turn "off" time of approximately 4 μsec, with a potential gain in excess of three million.

SIGNAL CONVERTERS

12,127 MODULATION AND DEMODULATION WITH SEMICONDUCTORS by D. P. Masher (MIT); U.S. Gov. Res. Rep., Vol. 35, p. 622(A), May 16, 1961 PB 154 843

An investigation of modulation and demodulation systems employing transistors is reported. A classification system which considers linear, time-varying systems as first order, and nonlinear, square-law systems as second order has been established. Further distinction is made between continuous-data systems in which the sensitivity function exhibits only discrete zero crossings, and sampled-data systems in which the sensitivity function possesses some characteristic distribution of finite intervals where the function is zero. The use of transistors as controlled-sensitivity devices is discussed for grounded-base and -emitter operation. Results derived experimentally from carrier-present and -suppressed systems which utilize transistors as time-varying parameters indicate that the transistor systems exhibit limited frequency response because of the intrinsic nature of the transistors, and that transistors offer no decided advantages over vacuum tubes with respect to linearity and distortion-free operation but are better than diodes.

12,128 PULSE CODE MODULATION. Part I. by J. S. Whyte (P. O. Res. Sta., England); P. O. Elect. Engrs. J., Vol. 54, Part 2, pp. 86-91, July 1961

Pulse code modulation, in which analog signals are represented by sequences of on/off pulses, is described. The effect of noise picked up on a transmission path is greatly reduced and a transmission performance which is independent of the length of the circuit is achieved. Basic principles of pulse modulation are discussed and applications are suggested.

12,129 MAGNETIC PHASE CORRECTION CIRCUITS by R. C. Barker and A. J. Gruodis (Yale U.); U.S. Gov. Res. Rep., Vol. 35, p. 570(A), May 16, 1961 PB 171 542

Techniques for integration and differentiation of the modulation on suppressed-carrier signals, using solid state and magnetic components, are discussed. All of the techniques developed make use of saturable magnetic cores, because they lend themselves to both long and short range storage of electrical signals, a function necessary in any system having other than a flat frequency response. Specifically, circuits have been developed which differentiate and integrate the modulation on a suppressed-carrier signal by, respectively, taking finite differences and by accumulation. Also, techniques for altering magnetic amplifier design to produce integration and differentiation are discussed. In all cases the emphasis has been placed upon the basic theory of operation rather than design for particular specifications. It has been shown that the different types of integrators and differentiators have many basic features in common, and recognition of these basic features is essential to the full exploitation of these circuit techniques.

12,130 DATA PHASE-CODING SYSTEM USING PARALLEL PULSE INJECTION IN BINARY DIVIDER CHAIN by F. J. Delaney (Collins); U.S. Pat. 2,994,790, Issued Aug. 1, 1961

Means for translating pulsed binary information into incremental phase variations of a carrier or subcarrier frequency are discussed. A phase-pulse modulation generator presented has the following characteristics: an accurate output phase which does not require readjustment, an output phase unaffected by temperature and supply voltage variations; an output phase unaffected by amplitude changes caused by instabilities common to electronic equipment; an output amplitude independent of the phase-shift generated; single timing input for simultaneous dual-channel data input operation. Precision components beyond those necessary to maintain frequency stability of the fixed frequency source are not required; high data-input impedances and magnetostrictive components are also not required. The system is smaller, lighter and consumes less power. Incremental phase translation of this nature represents a type of modulation that can be used to transmit any type of information capable of digital representation. It may be employed to transmit a teletypewriter signal or sampled bits of a continuously varying signal.

Laser Modulators and Demodulators - See 12,041

12,131 A STATIC ELECTRONIC FREQUENCY CHANGER by D. C. Griffith and R. M. Vemer (Thompson RW); IRE Intl. Conv. Rec., Vol. 9, Part 5, pp. 342-348, Mar. 1961

Semiconductor step-down frequency converters without a dc link are described. They are adaptable for fixed or variable input frequencies and for fixed or variable output frequencies. The systems described use a waveform generator to drive logic and control circuits which in turn control the Si-controlled-rectifiers. High efficiency, low cost and simplicity are claimed for the unit. The use of a reference waveform generator allows variation of the output waveform, frequency, phase and voltage.

WAVE GENERATORS

12,132 PULSE GENERATOR CIRCUIT by J. B. Force (Genl. Motors); U. S. Pat. 2,991,429, Issued July 4, 1961

A transistorized pulse generator of simple circuit design which is capable of delivering pulses of relatively high power to a load at a selected pulse repetition rate and duration is described. An RC timing circuit controls the conduction of a

transistor amplifier. Separate capacitors may be used to control the pulse width and pulse duration, or a single capacitor may be used to give a pulse "spike" at selected repetition rates.

12,133 TRANSISTORIZED TWENTY-PULSE GENERATOR by R. W. Leurgans and H. Thiel (Electronic Def. Labs.); U. S. Gov. Res. Rep., Vol. 36, p. 35(A), Sept. 5, 1961 AD 258 863

A transistorized multipulse generator which has been designed, built and tested to evaluate problems encountered in miniaturization of multipulse generators is described. Individual units of the generator are described and results of various tests are reported. Space and power requirements are considerably reduced over those of a tube-type generator, but the cost of the transistorized units is higher.

12,134 NEW WAYS TO TRIGGER AVALANCHE PULSE CIRCUITS by H. G. Dill (Hughes Prod.); Proc. IRE, Vol. 49, p. 1093(L), June 1961

A circuit consisting of a base triggered avalanche transistor with a tunnel diode in the base and an emitter-triggered avalanche transistor circuit are described. The latter circuit uses a tunnel diode between emitter and ground and has the following features: (1) dc bias can easily be adjusted from the base side; an inhibit circuit may be used. (2) I_E is low during the standby period which allows biasing the tunnel diode closely to the switching threshold. (3) The tunnel diode is automatically reset. (4) A time delay of 2-4 μsec between input and output depends on the lead inductance and stray capacitance. Both circuits have a high sensitivity, and no feedback of pulse energy into the trigger circuit is observed.

12,135 NEUTRALIZATION OF INTERELECTRODE CAPACITANCE IN TRANSISTOR PULSE CIRCUITS by J. P. Eckert, Jr. (Sperry Rand); U.S. Pat. 2,987,627, Issued June 6, 1961

A transistor pulse circuit with means for inhibiting undesired feedback between the output and input is described. The circuit consists of a transistor operated in combination with a power pulse source for regularly keying a load into the transistor output circuit. Since a prime cause of undesired power pulse feedback is due to collector-to-base interelectrode capacitance when the transistor is in the grounded emitter configuration, a pulsed voltage source connected to the input and keyed by the power pulse is employed to neutralize this capacitance. This results in an output waveform of excellent shape.

12,136 DELAYED PULSE GENERATOR WITH EXPONENTIALLY FUNCTIONING VOLTAGE COINCIDENCE TIMER by J. W. Taylor, Jr. and R. E. Reise (Westinghouse); U. S. Pat. 2,997,601, Issued Aug. 22, 1961

A time modulator system which produces a delayed output pulse with the delay time linearly proportional to an applied control variable is described. An exponential saw-tooth generator is triggered by a reference pulse and its output applied to an amplitude comparator circuit. An adjustable dc control voltage is also applied to the comparator and an output pulse is generated when the sawtooth magnitude is equal to the dc control voltage. The control voltage is also an exponential voltage to provide a linear time interval between the reference pulse and the output pulse. The circuit is used in radar range measuring systems to measure the time interval between a transmitted radar pulse and a target echo pulse.

12,137 FOUR LAYER DIODE TRIGGERS HIGH VOLTAGE PULSE GENERATOR by N. C. Hekimian and P. M. Schmitz (Dept. Def., Wash., D.C.); Electronics, Vol. 34, pp. 84-85, June 30, 1961

A solid-state pulse generator which is simple, uses little standby power and has a low peak-to-average power requirement is described. A fail-safe circuit prevents current conduction from the power supply during the pulse. Circuit details are given for a 10,000 pps generator with an output of 1300 v and pulse width of 7 μsec. An electrostatic head for electrographic recording presents the load together with a 200 K series resistor. This circuit is also applicable to high-voltage, low-current supplies such as required for Geiger counters.

12,138 QUADRATURE STRIPPING NETWORK by G. Wennerberg (Lear); U.S. Pat. 2,982,867, Issued May 2, 1961

An improved quadrature stripping network in which a substantially square wave output voltage corresponding to input signals is developed with minimum delay is described. The square wave voltage produced is insensitive to waveform variations and quadrature effects in the input signal. Two pairs of switching devices (diodes or transistors) are employed for charging and discharging a capacitor to obtain a square wave voltage lagging the ac signals by only a half cycle. The circuit contributes to a servo amplifier system which is light in weight and occupies little space.

PULSE CIRCUITS

12,139 DIFFERENTIAL FREQUENCY RATE CIRCUIT COMPRISING LOGIC COMPONENTS by J. Dobbie (Westinghouse); U.S. Pat. 2,985,773, Issued May 23, 1961

A differential rate circuit which provides an output on either of two lines equaling the difference in pulse rates received is described. The basic logic element employed in the device is a transistor NOR circuit. With no input to the NOR circuit, the transistor is cutoff and an output is obtained; with an input, on any or all of the input lines, the transistor becomes saturated and no output occurs. The differential rate circuit employs six NOR logic elements and two flip-flops, each comprising two cross-coupled NOR elements.

12,140 PULSE CONTROL SYSTEM by J. C. Sims, Jr. (Sperry Rand); U.S. Pat. 2,992,416, Issued July 11, 1961

A pulse control system which may function as a serial-to-parallel converter, a pulse group synchronizer, and as a code changer is described. Input signals are sent to a shifting register, each stage of which is connected to a magnetic core via diodes. The input information is successively advanced through each stage of the shifting register until the register is full; a control signal is then applied to a gating source which pulses the diodes into conduction and simultaneously transfers the information contained in the shifting register into the magnetic cores which are in parallel with each other. A delay is provided in the shifting register to allow this information transfer, after which the register is reset to accept the next pulse train. By providing successive rows of cores and adding further control circuitry, the circuit may be used to synchronize a pulse group as well as providing serial-to-parallel conversion. Code changing may be effected by providing a core matrix of differing input and output dimensions.

12,141 TIMING OF REGENERATIVE PULSE REPEATERS by F.T. Andrews, Jr. and E. E. Sumner (Bell Labs.); U.S. Pat. 2,922,341, Issued July 11, 1961

A timing system of regenerative pulse repeaters which was developed for the purpose of increasing the accuracy and reliability of pulse transmission is described. The system employs a self-timing arrangement in which a timer, including a tuned circuit, is made responsive to the pulse repetition frequency of the received pulse train. The system takes various forms with respect to both the degree of combination effected and the circuitry employed. For example, in one form the complete timing wave is combined with the pulse output and in another form only a part of the timing wave is combined with the pulse train output. A regenerative pulse repeater consisting of an input transformer coupled to an equalization network is described. The output of this equalization network is applied to a preamplifier which, in turn, is connected to both the regenerator and the timer. The block and circuit diagrams are given with detailed descriptions of the operating principles.

OTHER CIRCUITS

12,142 INCREASING THE Q OF A FILTER THROUGH THE USE OF TUNNEL DIODES by D. Sabih (Hughes Aircraft); Solid State J., Vol. 2, pp. 30-33, June 1961

A technique of utilizing the negative resistance characteristic of a tunnel diode to reduce or cancel out the ohmic losses in electric filters, thereby gaining an increase in filter selectivity, is described. A 10 Mc filter was built with initial Q of 20, but with the introduction of the tunnel diode in the filter circuit and proper adjustment, the Q of the filter was raised to 833. A mathematical treatment of the design criteria and a discussion of the stability problem are presented.

12,143 TRANSISTOR CONTROL SYSTEM by J. G. Isabeau (Zenith); U.S. Pat. 2,997,603, Issued Aug. 22, 1961

A transistorized signal limiter which is not affected by transistor aging is described. The circuit uses a resonant circuit output load with a gated feedback loop from the collector to base. The feedback path is held open until the input exceeds a predetermined level. Variation of the input signal in one direction is limited by the gated feedback loop; in the other direction by transistor bias. A Zener diode voltage divider supplies bias voltages to avoid bypass capacitor charging with the resultant shift in the dc bias point. The circuit is useful as a limiter before a discriminator.

12,144 ADJUSTABLE CLAMP CIRCUIT SHIFTS A-C SIGNAL LEVEL by H. O. Hoadley (Kodak Res. Labs.); Electronics, Vol. 34, p. 104, May 19, 1961

An adjustable clamp circuit using a capacitor, two diodes and a potentiometer is described. By adjusting the ratio of the resistive loads for the positive and negative parts of an ac signal, the dc level of this signal may be shifted anywhere between the two limits of full clamping circuits.

12,145 ANALYSIS OF DRIFTS IN A TRANSISTOR CHOPPER by R. H. Okada (Moore School, U. Pennsylvania); IRE Intl. Conv. Rec., Vol. 9, Part 9, pp. 207-218, Mar. 1961

Drifts in transistor choppers used in dc amplifiers are discussed. The sources of such drifts are analyzed and formulas are derived to show the effects of drift. The use of a silicon transistor as the chopper element is discussed. The drift is found to be predictable, controllable and may be used to cancel out other sources of drift. An example of chopper design is given.

APPLICATIONS OF SOLID STATE DEVICES

SCIENTIFIC AND MEDICAL

Optical Masers as Intense Light Source in Micrography - See 12,045

Scientific Applications of Lasers - See 12,042

12,146 TRANSISTORIZED PACEMAKER FOR REMOTE STIMULATION OF THE HEART BY RADIO-FREQUENCY TRANSMISSION by L. Eisenberg, A. Mauro (Rockefeller Inst.) and W. W. L. Glenn (Yale U.); IRE Trans., Vol. BME-8, pp. 253-257, Oct. 1961

Techniques for controlling the cardiac rate by external means when normal physiological processes fail to maintain a stable rate are described. The factors in the choice of radio-frequency transmission technique are presented and evaluated, and a set of design specifications is evolved based upon the physiological needs of the patient. The design of two transistorized, battery-operated pacemakers is presented in detail with a description of the constructed units and an evaluation of performance. The units have been successfully used on five patients.

12,147 A PORTABLE MINIATURE TRANSISTORIZED RADIO-FREQUENCY COUPLED CARDIAC PACEMAKER by D. M. Hickman, L. A. Geddes, H. E. Hoff, M. Hinds, A. G. Moore, C. K. Francis and T. Engen (Baylor U.); IRE Trans., Vol. BME-8, pp. 258-262, Oct. 1961

A miniature, transistorized radio-frequency-coupled cardiac pacemaker, which eliminates wires penetrating the skin when electrodes are placed on the heart to drive it, is described. The design eliminates the need for totally implanting a pacemaker with its batteries. The stimulating impulse is transmitted by AM to a tuned circuit and detector assembly implanted below the skin. The detector output is connected to electrodes directly on the heart, making external control of the heart rate possible. The pacemaker transmitter, which is 4x1-3/4 x 1-1/2 in and weighs three oz is placed on the surface of the body above the receiver implant.

12,148 MEASURING EYEBALL PRESSURE WITH A CRYSTAL OSCILLATOR by D. E. Newell, C. H. Horn (State U. Iowa) and M. L. Rubin (State U. Iowa Hospital); Electronics, Vol. 34, pp. 64-65, Sept. 8, 1961

A transducer capable of converting small pressure changes with infinitesimal mechanical displacement into frequency shifts in a quartz crystal controlled oscillator is described. The transducer signal is multiplied and mixed with the output of a local

SCIENTIFIC AND MEDICAL (Cont'd)

oscillator; the difference is detected and used to drive a monostable multivibrator which converts the frequency shift into constant energy pulses that change in repetition rate due to pressure. These are integrated and measured. One of the units constructed has a sensitivity of 0.5 cm per mm Hg recorder deflection. The instrument is useful in diagnosing glaucoma by measuring intraocular pressure.

Medical Applications of Lasers - See 12,042

12,149 INFLUENCE OF LIGHT AIR IONS ON HUMAN VISUAL REACTION TIME by M. Knoll, J. Rheinstein (Inst. for Tech. Electronics), G. F. Leonard (Computer Assoc.), and P. F. Highberg (Princeton U.); IRE Trans., Vol. BME-8, pp. 239-245, Oct. 1961

An automatic electronic visual-reaction-time meter, which includes a random-pulse generator controlled by nuclear radiation for starting the subject's light pulse, is described. Several hundred subjects have been investigated in over 12,900 tests, using the meter. The influence of light atmospheric ions on the human reaction time has been found for ion currents between 10^6 and 10^9 inhaled ions per second or ion densities of about 10^3 to 10^6 ions/cm^3. Inhaling positive or negative ions may increase or decrease the reaction time after several hours. The influence of ions resembles the effect of many drugs on the human system. The effect disappears when the subject breathes through the nose instead of the mouth.

12,150 SIMULATING NERVE NETWORKS WITH FOUR-LAYER DIODES by A. J. Cote, Jr. (Johns Hopkins U.); Electronics, Vol. 34, pp. 51-53, Oct. 13, 1961

The neuristor, an electronic model of the neuron's axon, is described. The model is an active transmission line which propagates a pulse without attenuation. Arrays of neuristors can serve as the only elements required in the synthesis of digital logic functions. A lumped-element neuristor can be formed from an appropriately coupled cascaded string of monostable trigger circuits. Four-layer diodes are used as the active elements with a bilaterally symmetrical biasing network. The model breaks down temporarily in the vicinity of the trigger point, with the breakdown spreading outward in both directions. Experiments have been conducted with a ten-diode model (10 section). For parameter variation, velocity of propagation of pulses ranged from 2 - 20 μsec per section with a minimum pulse spacing of 1 - 6 msec.

12,151 ELECTRICAL ANALOG SIMULATION OF TEMPERATURE REGULATION IN MAN by R. J. Crosbie, J. D. Hardy, and E. Fessenden (U.S. Naval Air Dev. Ctr.); IRE Trans., Vol. BME-8, pp. 245-252, Oct. 1961

Construction of a transistorized electrical analog to simulate the physiological responses of a man to heat and cold is described. The basic equations for heat balance have been developed to take into account heat losses by radiation, convection and evaporation. Physiologic temperature regulation involves three basic types of control modes: proportional control, rate control and some of the characteristics of an on-off control. The simulator predicts steady-state situations of rectal temperature, skin temperature, metabolic rate, vasomotor state and evaporative heat loss under both resting conditions and exercise. Dynamic responses to sudden shifts in temperature, air velocity, relative humidity and metabolic rate can be simulated to a considerable extent.

Four-Channel Scintillation Magnetic Recorder for Medical Studies - See 12,159

MILITARY AND COMMERCIAL

Laser Ranging System - See 12,040 and 12,043

12,152 TRANSISTORIZED REMOTE CONTROL IN RAILWAY SIGNALLING by J. P. Coley (Westinghouse Brake & Signal); Brit. Commun. Electronics, Vol. 8, pp. 742-747, Oct. 1961

A scanning type of railway signalling system using transistorized devices which requires only one or two pairs of wires is described. Sets of synchronized stepping or counting chains are employed, and actual transmitted information is dependent on the selection of distinctive carrier frequencies. Transistor switches are utilized to take advantage of their high switching speeds and more reliable operation. A large control area which permits more efficient handling of traffic is obtainable without the high cost of multiline cabling by application of the described system.

Laser Communications Systems - See 12,040

12,153 A NEW APPROACH TO TRANSISTORIZATION OF MOBILE RADIOTELEPHONE EQUIPMENT by I. Teose (Intl. Sys., Ltd.); IRE Intl. Conv. Rec., Vol. 9, Part 8, pp. 206-213, Mar. 1961

The design of a fully transistorized vehicular transmitter-receiver and its advantages over conventional equipment are discussed. Low power drain, ease of maintenance and small physical size are listed as the particular advantages. A circuit by circuit comparison of the transistor circuits with vacuum tube circuit performance is carried out.

12,154 THE HIGH-BEAM-VELOCITY VIDICON by J. Dresner (RCA); RCA Rev., Vol. 22, pp. 305-324, June 1961

The construction of Vidicons with high sensitivity and fast response is discussed. Capacitive lag which, when the scanning beam lands at low velocity, necessitates the use of porous photoconductors having generally low sensitivity is the limiting parameter. It is demonstrated that this capacitive lag can be reduced to a very low value by making use of a scanning beam landing at high velocity. It is then possible to utilize glassy photoconductive layers of high sensitivity and large capacitance. The redistribution problems associated with high-beam-velocity operation are studied in detail. An experimental tube which uses a glass Sb_2S_3 photoconductive layer with a capacitance of 8000 picofarads is mentioned. The speed of response with a high-velocity beam is considerably faster than with a low-velocity beam. Image quality is adequate for many purposes.

12,155 TRANSISTORIZING THE INDUSTRIAL IMAGE ORTHICON CAMERA by R. W. Cook (Thompson RW); IRE Intl. Conv. Rec., Vol. 9, Part 6, pp. 48-56, Mar. 1961

The design of a fully transistorized image orthicon camera is described. Detailed circuit descriptions in areas such as the preamplifier, shading circuits and focus current regulator point out the advantages transistors offer. These advantages include a substantial reduction in weight, size, cost and operating power. Charts and photographs are used to describe in detail the sensitivity, capabilities and applications of such a camera.

12,156 SPEAKER EQUIPMENT FOR SUBMARINE CABLE SYSTEMS by M. Stephenson and L. A. Redburn (Main Lines Dev. and Maint.); P. O. Elect. Engrs. J., Vol. 54, Part 2, pp. 118-121, July 1961

The use of standard engineering speaker equipment in conjunction with submarine cable systems is discussed. An omnibus circuit is provided linking all stations as well as two local speaker circuits for use between adjacent stations. The omnibus circuit, which employs 2 vf code signalling, is operationally compatible with the omnibus speaker circuit provided on the TAT-1 cable system. The transistorized equipment is of the 51-type construction.

12,157 AN ACTIVE RADAR SURVEILLANCE BEACON by A. R. Almond and D. F. Gumb (Aero. Geo. Astro.); IRE Intl. Conv. Rec., Vol. 9, Part 5, pp. 28-37, Mar. 1961

An active radar surveillance beacon which makes use of a traveling-wave amplifier tube and a transistorized augmentor circuit was discussed. The augmentor features a loss of signal-destruct-annunciator, a regulated input, a dc-to-dc converter, and a time delay circuit for allowing the filament of the traveling-wave tube to warm up before application of high voltage. The traveling-wave tube provided a minimum sensitivity of −45 dbm and a maximum saturated power of 1 w over a 300 Mc bandwidth.

12,158 TRANSISTORIZED MTI CANCELLER by C. J. Meiselbach (Airborne Instr. Lab.); U.S. Gov. Res. Rep., Vol. 35, p. 566(A), May 16, 1961 PB 153 888

An engineering model of moving target identification (MTI) which demonstrates the feasibility of manufacturing transistorized and miniaturized cancellation equipment with electrical performance characteristics comparable with those of tube equipment is described. The model is 0.75 cu ft in volume, is completely transistorized (using 91 transistors) and operates on 10 w of power. A miniaturized 2778 μsec folded ultrasonic delay line mounted in a temperature-controlled oven is used to determine the system PRF. The Canceller includes automatic pulse amplitude and timing circuits that maintain a cancellation ratio in excess of 36 db for extended periods and operates satisfactorily over a temperature range of 5° to 45°C.

Radar Pulse Generator-Modulator - See 12,136

12,159 FOUR CHANNEL MAGNETIC TAPE SYSTEM FOR MEDICAL STUDIES by R. Hindel (Atomium) and G. J. Hine (V.A. Hosp., Boston); IRE Intl. Conv. Rec., Vol. 9, Part 9, pp. 56-66, Mar. 1961

A four channel gamma ray scintillation system which uses a four track, four speed magnetic tape recorder as a data storage device is described. A linear output rate meter is included as well as logarithmic and ratio circuits. The photomultiplier preamplifier drives a Schmitt trigger and two binary scaling stages. Both record and playback circuitry is described.

12,160 THE COURIER RECORDER-REPRODUCERS by J. P. Buffington and S. L. Wiig (Consol. Electrodyn.); IRE Intl. Conv. Rec., Vol. 9, Part 5, pp. 241-249, Mar. 1961

The electronic and mechanical features of the Courier data storage system are discussed. A transistorized inverter supplies the 400 cycle synchronous drive motor with 6 w power at 96 v. A novel inverter inductor saves weight by operating as a unity turns ratio auto-transformer. The recorder amplifier circuit utilizes an emitter-follower common emitter pair which drives a conventional differentiator and Schmitt trigger pulse former. A pair of emitter-follower head drivers reverse the direction of another constant current of 10 ma through the head winding.

Harmonic Analysis of Saturation Recording in a Magnetic Medium - See 12,185

Magnetic Switching Circuit for Recorder Head - See 12,123

12,161 ELECTRONIC MUSICAL INSTRUMENT by R. H. Peterson; U.S. Pat. 2,924,184, Issued Feb. 9, 1960

The structure and design of oscillators for an electronic organ are described. To secure effective control of the rates of attac and decay when a note is played, the amplitude of the signals generated by the oscillators corresponds roughly to the activating voltage supplied to the oscillators, and there is no material variation in frequency over the entire range of amplitudes. This is accomplished by providing high-Q tuned circuits for the oscillator section, using components which are stable with respect to aging, temperature, and humidity changes. The physical layout of the inductive components is such that magnetic interference is avoided even though the units are packaged in a space which is only a small fraction of that previousl required. This is brought about by the use of a ceramic, insulating, ferromagnetic material.

COMPUTERS

DIGITAL COMPUTERS

12,162 THE PHYSICS OF COMPUTER ELEMENTS by C. N. W Litting (U. Manchester); Brit. J. Appl. Phys., Vol. 12, pp. 207-213, May 1961

The basic requirements of a computer and some novel means of satisfying these requirements are discussed. The operations considered are the reception and storage of information, the performance of logical operations on the information and the production of some form of useful output. The main use of novel techniques is in the storage of information, and various systems which depend on different physical principles are examined. The following types of system are considered: acoustic, electrostatic, magnetic, optical and superconducting. At present magnetic or superconducting devices employing thin films show most promise for the development of high speed devices.

12,163 THE "PASCAL", A FAST DIGITAL ELECTRONIC COMPUTER FOR THE PHILIPS COMPUTING CENTRE by W. Nijenhius (Philips Res. Labs.); Philips Tech. Rev., Vol. 23, pp. 1-18, Oct. 1961

The PASCAL, a digital electronic computer, is described. The computer is a binary parallel machine of the single address type with a word length of 42 bits. The memory consists of a magnetic core memory with 2016 words, a drum memory with 16,384 words, magnetic tape units with about 10^6 words per tape, a plug board memory with 16 words, and a modification memory with 8 half-words. Computation is possible with fixed or floating point notation; in fixed-point notation, an addition takes about 10 μsec and a multiplication about 71 μsec. On the

average, 60,000 instructions are processed per second for a typical program. Input and output take the form of punched tape, punched cards, or magnetic tape; a line printer can also be used for the output.

12,164 ELEMENTS AND UNITS OF A DIGITAL COMPUTER ONE-CYCLE PARALLEL ARITHMETIC DEVICE WHICH USES FERRITE TRANSISTOR CELLS by M. I. Petrukhin (Acad. Sci., USSR); Automn. Remote Control, Vol. 22, pp. 172-179, Sept. 1961

The design of a single-cycle parallel digital computer using ferrite-transistor cells is described. The cell consists of a square-loop ferrite core and a transistor. Two series-connected cells make up a composite cell. The use of the ferrite-transistor cells in a shift register, time delay circuits and a trigger with nonsymmetrical outputs is described.

12,165 INFORMATION-HANDLING APPARATUS by K. E. Schreiner and B. L. Havens (IBM); U.S. Pat. 2,987,253, Issued June 6, 1961

An information handling apparatus which employs phase modulated waves to represent information is described. The system operates in the microwave frequency range. The information from the sources is first translated into phase modulated waves, distinguishable from one another as to phase. Means are provided for sensing the phases of these phase-modulated waves and for controlling the phase of a phase-modulated output wave in accordance with the result of the sensing operation, to indicate by the phase of the output wave the result of combining the information from the sources in accordance with the given rule. Details of system operation are given. An illustrative system is described in which the apparatus is employed in a binary full adder.

12,166 RESEARCH ON OPTO-ELECTRONIC COMPUTER COMPONENTS by H. O. Hook and E. C. Giaimo (David Sarnoff Res. Ctr.); U.S. Gov. Res. Rep., Vol. 36, p. S-55(A), Aug. 20, 1961 PB 155 537 $6.60

Opto-electronic digital circuits using electroluminor and photoconductor components are discussed. At present these circuits attain minimum switching times of approximately 50 milliseconds. Although per-element powers are about 10^{-5} watt, the low speed prohibits the practical use of opto-electronic circuits in arithmetic circuits. In input, output and image processing, however, the advantages of parallel processing using neighborhood interaction, threshold logic and negation seem to more than overcome the relative slowness of each cell. Line thinning and thickening, hole fill-in, outlining or fimbriation, motion detection, intersection detection, and negation were demonstrated, and de-noising, speck removal, and character simplification seem feasible. Special photoconductor cells may provide an input to a high-speed nonscanning character reader.

Optical Computer Using Lasers - See 12,041

Logic Circuit Synthesis - See 12,053

12,167 DIRECT COUPLED TRANSISTOR LOGIC USING COMMONED EMITTERS AND COMPLEMENTARY LOGIC BLOCKS by R. M. Meade (IBM); U. S. Pat. 3,005,112, Issued Oct. 17, 1961

Logical circuitry employing the "third level" scheme of control is described. The third level signal drives one or more transistors in the logical block to which it is applied towards a heavier than normal conduction, thus overriding the existing function of the logical block when present. The signal performs the functions of a supervisory, control, or gating signal without requiring special gating circuitry; conversion from normal to third level logic is accomplished by changing the values of the components in the inter-block coupling network. The basic logical unit called the "forcing circuit" is first described. This unit delivers a pair of complementary signals in accordance with the state of the input signals and the control or third level signal. From this combinational circuit a sequential circuit is formed by utilizing one or more of the outputs as input signals. Third level logic is then applied to sequential forcing circuits consisting of a data latch, bipolar set trigger, register circuits, and a race free escapement gate.

12,168 DESIGNING NOR CIRCUITS FOR MAXIMUM RELIABILITY by K. M. Trampel (IBM); Electronics, Vol. 34, pp. 46-48, June 2, 1961

A design procedure, under worst-case conditions, for a p-n-p transistor saturating voltage mode NOR circuit is presented. The typical design example is a 3 input NOR circuit which can drive 3 output loads. The nominal up and down levels (logical "1" and "0") are 0 and −6 volts, respectively. The design procedures consist of examining the worst-case "off" condition which is when all 3 of the inputs are at ground level and examining the worst-case saturation condition which is when 2 of the 3 inputs are at ground level and the transistor is saturated. One of the advantages of this circuit is that power dissipation in the transistor is small. The major disadvantage is its low operating speed.

12,169 BILATERAL SWITCHING USING NONSYMMETRIC ELEMENTS by M. Aoki and G. Estrin (U. California); IRE Trans., Vol. EC-10, pp. 42-50, Mar. 1961

Bilateral switching using nonsymmetric elements and the designs of such systems are described. Magnetic-core memory elements characteristically require bipolar applied fields. The vanishing inner diameter of toroids and the loss of the third dimension entirely in deposited thin films demands minimization of the number of wires. A configuration which has been investigated and applied in a word organized memory is illustrated. It consists of a pair of mutually inverted and parallel connected transistors that are not in general symmetrical. Some of the system considerations which determine the important design parameters are discussed. Methods for the location of regions of satisfactory operation in the many-variable space of the inverted transistor pair are described.

12,170 INFORMATION HANDLING APPARATUS by K. E. Schreiner (IBM); U.S. Pat. 2,987,630, Issued June 6, 1961

A system designed to mechanize various logical operations is described. Operations such as "OR", "AND", "EXCLUSIVE OR", "BINARY ADDITION", etc., are performed by feeding the information contained in phase-characterized signals into microwave elements such as T waveguide junctions, diode rectifiers and modulators, etc., which comprise the information-handling system. The output of this system is itself a phase-characterized wave whose polarity is an indication of the results of the logical operation. The system is capable of employing microwaves of very high frequency (10 kilomegacycles or more).

12,171 MAGNETIC LOGIC CIRCUITS EMPLOYING MAGNETIC RELAY COMPONENTS by E. P. Stabler (GE); U. S. Pat. 2,988,649, Issued June 13, 1961

A novel magnetic element which can be employed in combination to provide numerous logical operations is discussed. The basic magnetic relay component comprises a continuous magnetic core structure in the form of first, second, and third flux paths or legs forming three junctions. The legs are curved to minimize flux leakage and facilitate the flux changes that must take place during the operation of the network. Three additional non-continuous legs are also joined (one at each junction) to the ferrite core to serve as one input and two output legs. The component is information biased in one of two conditions so as to provide an output signal at one of two disjoint outputs in response to a readout signal. The network illustrated acts to steer flux changes through either a first or second path to one of the disjoint outputs in accordance with the input information in the same fashion as an electrical relay steers current. Circuit details are given and two other embodiments of the device are used to illustrate the applications of the device in performing logical operations.

12,172 UNIVERSAL LOGICAL PACKAGE by F. R. Dean (Computer Control); U.S. Pat. 2,999,947, Issued Sept. 12, 1961

A single, reliable, transistorized, logical package which fulfills substantially all needs in most computer systems while effecting maximum economy is described. Component wastage, physical space and power consumed are minimized. A simplified means for inhibiting the entire logical package by controlling the potential on a single input terminal is provided. The device is capable of handling any combination of three variables and may be adapted to serve as a flip-flop, half-adder, shift register stage, or comparator by appropriately interconnecting readily accessible terminals. The package is especially suited for manufacture by printed circuit board production techniques. The device operates at relatively high speed and is adapted for interconnection with a plurality of like packages and well-standardized electronic assemblies such as power supplies, clock pulse sources, and binary data storage apparatus.

12,173 TRANSISTOR SWITCHING CIRCUITS INCLUDING AN INVERTER STAGE DRIVING AN EMITTER-FOLLOWER STAGE by L. R. Harper (IBM); U.S. Pat. 3,003,070, Issued Oct. 3, 1961

A switching circuit for use in high speed computers is described. The output is dynamically driven during turn-on and turn-off to reduce switching time. The input is applied to an inverter which is direct coupled to an emitter follower. When the emitter follower is on, the transistor is saturated and minority carriers are stored. When the emitter follower is turned off by an input to the inverter, the stored carriers provide a transient low impedance between emitter and base, cutting the output off quickly. A trigger circuit is provided by cross-coupling two of the units.

12,174 TRANSISTOR LOGICAL CIRCUIT by R. A. Henle (IBM); U.S. Pat. 3,003,071, Issued Oct. 3, 1961

A complemented EXCLUSIVE OR circuit which indicates correspondence or non-correspondence between two inputs is described. Two signal input transistors have their collectors common to one signal output. Two non-correspondence detecting transistors are emitter-coupled to the input transistors, with bases and emitters cross-coupled and their collectors common to a second signal output. When the input signals correspond, the input transistors are on and the detecting transistors are off. With different inputs, one input transistor and one detecting transistor are on, producing a different set of signals at the two complementary output terminals.

12,175 APPLICATIONS OF TUNNEL DIODES IN IMPULSE TECHNOLOGY [in German] by U. Rohde and H. J. Thaler; Elektronik, Vol. 10, pp. 33-38, Feb. 1961

The application of tunnel diode circuitry to miniaturized computer element construction is discussed. Tunnel diodes are characterized both by high small-signal sensitivity and by high switching speeds. A summary of important applications is given.

12,176 TRANSISTOR SWITCHING SYSTEM by P. H. Halpern (IBM); U.S. Pat. 2,985,771, Issued May 23, 1961

An N-stable device, comprising N-sets of transistors, which functions as a ring counter is described. The speed of response is limited only by the response time of the transistors employed since all sets are direct coupled to avoid the use of reactive coupling elements. Each set includes a gate, trigger, holding and pull-over transistor. A pulse passed by the gate transistor to the parallel connected holding and pull-over transistors renders conductive the pull-over and the associated trigger transistor. Upon removal of the pulse, the holding transistor becomes conductive and maintains the trigger conductive until the next pulse is applied. With application of the next pulse a gate, which has been conditioned by the preceding trigger, passes the pulse to the next set of transistors. This operation continues with the several sets being rendered conductive in sequence to complete the count of pulses applied by the clock.

12,177 TRANSISTOR COUNTING CIRCUIT HAVING RESISTOR AND DIODE INTERSTAGE COUPLING MEANS by V. Hofmann (Siemens AG); U. S. Pat. 3,005,917, Issued Oct. 24, 1961

A counting circuit which uses only one transistor per counting stage is described. The transistors are direct coupled from the collector of one stage to the base of the next by means of both resistance and diode coupling. In addition, resistive coupling extends from the collector of one transistor to the base of all other transistors except the one immediately following. By this means only one stage is nonconducting at a given time, all other stages being fully conducting. On application of an input signal, nonconduction switches to the next transistor in the counting sequence, increasing the count by one. Thus n transistors are required for a count-of-n circuit. With slight modification, the circuit may also be used to obtain a backward count.

12,178 TRANSFLUXOR COUNTING CIRCUIT by A. G. Samusenko (RCA); U. S. Pat. 2,988,653, Issued June 13, 1961

An improved storage type counting circuit whose counting ratio can be varied automatically by means of an electric control signal is described. The circuit is composed of a transfluxor comprising a multiapertured core of substantially rectangular hysteresis loop material, with a control winding linked through the first loop and input and output windings through the second loop. The control winding is connected to a control source

which supplies bias setting currents to the core, the amplitudes of which determine the counting ratio. This ratio may be varied in discrete steps. The input winding is connected to the input transistor which responds to the input pulses to be counted by applying a signal to the core for each input pulse. The output winding resets the core in conjunction with the output transistor to which it is connected. The core is reset and an output signal is obtained after the predetermined number of input signals has been received.

Pulse Train Converter Circuitry - See 12,140

12,179 DESIGN OF AN ALL-MAGNETIC COMPUTING SYSTEM: Part II-LOGICAL DESIGN by H. D. Crane (Stanford Res. Inst.); IRE Trans., Vol. EC-10, pp. 221-232, June 1961

A logical design technique for use with a previously described magnetic "OR" module is presented. The module forms the (inclusive) OR function of two input variables. This function can subsequently be transmitted to three receivers, each transfer being independently logically positive or negative. The read-outs are nondestructive and the transmitter module must be explicitly cleared before read-in is again possible. In view of the relatively small fan-in and fan-out for this module, and since only the OR function can be directly formed during any single transfer, complex logic functions must be formed slowly, a step at a time. This step-by-step generation of functions results in the need for more modules than might otherwise be required, but aside from that, the synthesis techniques are much like those of customary logical design. The design of an arithmetic unit for decimal addition, subtraction and multiplication is outlined. Some comparisons between this particular all-magnetic logic scheme and conventional core-diode schemes are noted. Comparison between magnetic logic schemes in general and some other realization schemes such as logic-operated parametrons and conventional transistor systems are made.

12,180 BINARY ADDER CIRCUITS by S. T. Meyers (Bell Labs.); U.S. Pat. 2,992,339, Issued July 11, 1961

A binary adder in the form of a four-terminal diode bridge circuit having a storage device such as a capacitor or an inductor connected between one pair of diagonally opposite terminals is described. This adder, which consists of only passive circuit elements, simplifies the circuitry required for adding a pair of single digit binary numbers and improves the reliability of a simple adder, a comparator or a disparity recognizer.

12,181 A FAST NUMERAL READING MACHINE by G. Fougere, J. Preston (A. D. Little) and R. Farnsworth (GE); Electronic Engrg., Vol. 33, pp. 562-573, Sept. 1961

A transistorized machine capable of reading groups of three decimal digits which have been impact-printed on special foam plastic tape is described. Printing increases the transmission of light through the tape by about 30 times and recognition is obtained by a two-dimensional array of solar cells. Present use is limited to a rate of 150 characters per second although the system is capable of reading several thousand characters per second. By using a high level of information redundancy, it has been possible to maintain the error rate below 0.01 per cent as well as to accommodate a wide range of printing quality.

12,182 OPTICAL READOUT FOR CRYOGENIC CIRCUITS by B. Rabinovici (IBM); Rev. Sci. Instr., Vol. 32, pp. 747-748, June 1961

An optical readout circuit which uses the Faraday rotation of the plane of polarization of a plane polarized light by a paramagnetic medium in a magnetic field to sense digital data from a superconducting circuit is described. An optically flat, cerium doped glass disk is subjected to a magnetic field by current pulses. A light beam (5400 A) is directed through a polarizer onto the disk and reflected through an analyzer to strike a light detector circuit. The polarizer and analyzer are Glan-Thompson prisms set 90° out of phase with each other. The light detector is sensitive to any rotation of the plane of polarization caused by the disk. The rotary power of the disk measured in the visible region at 1.8°K was 12°/100 gauss mm.

Magnetic Printing Material for Computers - See 12,020

12,183 TRANSISTOR MEMORY SYSTEM by T. J. Tulp (Philips); U.S. Pat. 3,001,089, Issued Sept. 19, 1961

A transistor memory system operating on the principle of the presence of free charge storage in the base zone is described. Free charge storage may be imparted to the input transistor by means of incident light or by supplying current to its base for a short period of time. A chain of transistors is arranged in which each transistor, in the presence of free charge storage in its base zone, determines the free charge storage in the base zone of a succeeding transistor of the chain by means of interrogating pulses which act as a collector supply voltage. For proper operation it is required that in the intervals between two interrogating pulses any free charge storage which may have been injected has not leaked away. A repetition frequency of interrogating pulses of 100 kc has been satisfactorily employed. The arrangement may be used for shifting information given in binary code as in calculating machines or in automatic telephony.

12,184 TRANSISTOR MEMORY DEVICE by T. J. Tulp (Philips); U.S. Pat. 3,001,090, Issued Sept. 19, 1961

A transistor memory device employing the principle of free charge storage is described. Reading-in pulses are supplied between the emitter and the base zone so that a free charge is produced in the base zone. Interrogating pulses which occur after the reading-in pulses act as a collector supply voltage. A short time after the transistor has been read out, the free charge storage still available is erased so that the transistor is again ready for subsequent reading-in. The method of erasing the remaining charge employs a known positive feedback cricuit using a current-amplifying type transistor with a greater than unity.

12,185 HARMONIC ANALYSIS OF SATURATION RECORDING IN A MAGNETIC MEDIUM by B. Kostyshyn (IBM); IRE Intl. Conv. Rec., Vol. 9, Part 2, pp. 112-117, Mar. 1961

A theoretical equation describing the output of a magnetic saturation-type digital information storage system was presented. The output was related in terms of the physical, magnetic, and electrical parameters of the system. The equation was programmed for the IBM 704 Data Processing System but when it was applied to an experimental NRZ system, excellent agreement was obtained between the observed and calculated results. The phenomena of "peak" or "phase" shift and amplitude shift occurring for an isolated pair of adjacent "ones" at high bit densities were demonstrated and discussed.

The calculated dependence of the zero-to-peak output and the peak-and-amplitude shifts was shown for assorted parameter variations.

12,186 MAGNETIC DATA STORAGE by R. R. Everett and R. L. Walquist (Research Corp.); U.S. Pat. 2,988,735, Issued June 13, 1961

A digital data signal transmission system using magnetic drum storage, which provides almost immediate access for recording data and a high-speed access for readout, is described. The drum contains status channels which produce signals indicating the status of the drum registers and which actuate the read and write circuits. Data are written into the first empty drum register which comes under the drum writing heads. Readout is from full registers only, with the data held in a temporary storage register until called for by the data receiver. The drum feeds a sine wave, which identifies the drum register locations, to a timing pulse generator to produce accurately timed clock pulses.

12,187 A NONDESTRUCTIVE READOUT FILM MEMORY by R. J. Petschauer and R. D. Turnquist (Rem. Rand); Proc. WJCC, Vol. 19, pp. 411-425, May 1961

The design and operating characteristics of a thin film memory are described. The memory consists of a set of cores, each of which consists of a Co-Fe film and a Ni-Fe film. The former is used to store a bit, while the latter senses it. The system is insensitive to a 2:1 range in read current variations, and memory performance is not affected by temperature and other environmental factors. Cycle time of 1.5 μsec was achieved and experiments with the system indicate that cycle times in the neighborhood of 0.1 μsec can be achieved.

12,188 HIGH-SPEED MEMORY USES TUNNEL DIODE CIRCUIT by S. Takahashi and O. Ishii (Electrotech. Lab., Tokyo); Electronics, Vol. 34, pp. 66-68, Oct. 20, 1961

A 272 bit tunnel-diode memory, operating at 5 Mc, is described. Bistable circuits of one tunnel diode and one resistor store one bit each. The memory unit is a three-terminal element with the third terminal tied to a read-out amplifier. An ordinary point-contact diode at this terminal provides a means of selection among the elements connected to one amplifier. Non-destructive readout is used. The matrix plane is 17.5 x 22.5 cm and can be reduced to 9.5 x 8.5 cm with improved tunnel diodes now available. The memory element can be set or reset within 10 nsec; access time, including circuit delay, is 100 nsec and the cycle time is 200 nsec.

12,189 A HIGH TRACK-DENSITY SERVO-ACCESS SYSTEM FOR MAGNETIC RECORDING DISK STORAGE by A. S. Hoagland (IBM); IBM J. Res. and Dev., Vol. 5, pp. 287-296, Oct. 1961

The feasible track-density potential of random-access magnetic-disk storage where magnetic head positioning is essential is investigated. A novel servo-access concept (enclosed-loop head-positioning control which includes the record member) for track location and registration is considered in detail. This servo concept is investigated as a means of permitting automatic tracking as well as precision positioning. Inherent in such an access control technique is an enhanced suitability for interchangeable record members. Design and performance results for an access model operated at 154 tracks per inch are included.

12,190 MEMORY SYSTEM by K. Li (RCA); U. S. Pat. 2,988,731, Issued June 13, 1961

An electronic circuit that stores a signal level for an indefinitely long period of time is described. The circuit uses a three-aperture transfluxor core which is set to a flux level corresponding to the input signal level. A transistor oscillator circuit controlled by the transfluxor continuously applies an output signal to a converter circuit which changes the oscillatory output signal to an output level that is compared with the level of the input signal. When the compared signals are unequal, a feedback signal is generated which causes the flux level in the transfluxor core to change in the proper direction to equalize the output and input signal levels. The input signal may then be removed and the output of the converter circuit will remain at the corresponding input signal level. In practice, a millisecond is sufficient time for the circuit to settle to a steady condition.

12,191 MAGNETIC DATA CONVERSION APPARATUS by R. H. Fuller and D. A. Buck (Giddings and Lewis Mach. Tool); U.S. Pat. 2,987,707, Issued June 6, 1961

A binary information processing apparatus which converts numerical information in binary or coded binary form into time spaced signals absolutely equal or proportional in number to the value of the number originally represented in binary form is described. The device provides a simplified and reliable storage means for information in binary form, and permits repeated interrogation without destroying such information or requiring it to be moved. The necessity for a separate storage register in ordinary conversion apparatus is done away with, and a magnetic shifting register which serves also as a storage means, and yet which requires only two magnetic elements per binary digit or "bit" is provided.

12,192 ELECTROLUMINESCENT DEVICE FOR TEMPORARY INFORMATION STORAGE by J. W. Culp (Genl. Tel. Labs.); IRE Electron Dev. Mtg., p. 96(A), Oct. 1961

The feasibility of using electroluminescent elements as memory devices was discussed. This use of electroluminescent elements is based on the fact that such elements have a "memory" of pulse polarity lasting for several seconds. To store a binary 1, the element is supplied with a write pulse of negative polarity. Interrogation is accomplished with a positive read pulse, and a gated photomultiplier responds to the light output. To store a 0, no negative pulse is supplied. One particular phosphor gave a signal-to-noise ratio of 8 for a storage time of 20 msec and 10 for a storage time of 2 msec. The readout time was 2 μsec. Experiments indicate that high storage density can be obtained in a crossed-grid electroluminescent panel having a nonlinear resistance layer to eliminate cross-talk.

12,193 THE DEVELOPMENT OF A PHOTOMEMORY by C. E. Nielsen, Jr. (Hydel); U.S. Gov. Res. Rep., Vol. 36, p. S-57(A), Sept. 5, 1961 PB 156 875 $3.60

Research on the construction of a prototype photo-memory is described. The reading system has operated satisfactorily on 0.006 in wide bits over a limited plate area. A 4 x 4 in data plate containing 0.001 x 0.004 in bits is shown to be feasible. The writing system produced 0.006 x 0.020 in bits on film at the rate of 20,000 bits/sec.

12,194 TRANSISTOR GATING CIRCUIT by J. C. Logue and H. C. Goodman (IBM); U.S. Pat. 3,007,056, Issued Oct. 31, 1961

Amplification and control circuitry for magnetic core readout operations is described. The circuit includes a two transistor push-pull amplifier whose input is coupled to the readout sense winding and whose output is across a ferrite core transformer. A full-wave diode rectifier connected across the secondary winding of the ferrite transformer converts the bipolar signals from the readout sense winding into unidirectional positive signals which are then applied to a gated transistor output amplifier. This amplifier is connected in series with a transistor gate which maintains the output transistor in the "off" or nonconducting state in the absence of a gate control signal. An output is obtained only during the time when a readout signal may be present as indicated by the presence of a clock or gating pulse. This prevents spurious output signals due to the presence of "record" signals in the sense winding.

Integrated Shift Register - See 11,997

ANALOG COMPUTERS AND OTHER DATA HANDLING SYSTEMS

12,195 ANALOG COMPUTERS by C. E. G. Bailey (Solartron Electronic Bus. Mach.); U.S. Pat. 2,989,239, Issued June 20, 1961

An analog computer which overcomes the unreliability of operation at points of singularities when transforming from cartesian to polar coordinates is described. The resolver output is applied through an amplifier and relay contact to a motor-tachometer adapted to rotate a spindle. When the function causes the spindle speed to increase beyond a preset limit, a finger on the spindle closes a contact to trigger a flip-flop. The flip-flop operates a relay to break the connection between the amplifier and the motor, and to apply a constant voltage to the motor from a second amplifier. The value of r is held constant while ϕ is changed to bypass the singularity.

Hall Effect Analog Elements for Analog Computers - See 11,999

12,196 A TUNNEL DIODE FUNCTION GENERATOR by P. Spiegel (Philco); IRE Intl. Conv. Rec., Vol. 9, Part 2, pp. 164-174, Mar. 1961

A method of analog function generation in which tunnel diode networks provide step approximations of a desired graphical function is described. The advantages of such a function generator over photoformers and conventional diode voltage-biased networks are: high speed; simple circuitry eliminating the need for bias supplies; and potentially low cost, miniature fabrication. The ultimate usefulness of this type of function generator is largely dependent upon developments in the field of sampled data control systems. In testing the circuit high speed pulses, similar to those representing the sampled data, were applied to the function generator input. The output is in the form of pulses whose amplitudes are proportional to the desired function of the input. A model with variable resistors proved the feasibility of this technique by allowing the generation of various arbitrary functions.

12,197 ELECTRONIC COMPUTER CIRCUIT by H. Schmid and J. L. West (Genl. Precision Lab.); U.S. Pat. 3,005,113, Issued Oct. 17, 1961

A circuit which provides an output potential varying in accordance with the square root of one or more independent variable inputs is described. The circuit generates square wave pulses which are then both amplitude and time modulated to provide the desired relation. An accuracy of better than 0.05 per cent of full scale output for input voltages between 1 mv and 10 v, and a zero offset of less than 0.05 per cent at zero signal input conditions is obtained. The circuit may be modified to accept both positive and negative input signals; in this case the output changes sign as the input changes sign, and no instability is encountered as the input passes zero. The circuit is relatively simple and requires no critical or otherwise unusual components.

12,198 AN ACCURATE ANALOG MULTIPLIER AND DIVIDER by E. Kettel and W. Schneider (Telefunken Res. Inst., Germany); IRE Trans., Vol. EC-10, pp. 269-272, June 1961

An analog circuit which allows simultaneous multiplication of two quantities, $x_1 \cdot x_2$, and division by a third, x_3, is described. The output is $\frac{x_1 \cdot x_2}{x_3}$. When transistor switches are employed, the error is $1 \cdot 10^{-4}$ machine units only. The zero error for x_2, used for amplitude modulation, can be reduced to $2 \cdot 10^{-5}$ machine units.

Hall Effect Multipliers - See 12,000

12,199 THE HALL-EFFECT ANALOG MULTIPLIER by G. Kovatch and W. E. Meserve (Cornell U.); IRE Trans., Vol. EC-10, pp. 512-515, Sept. 1961

The application of the Hall effect to a general purpose four-quadrant multiplier is discussed. Circuit diagrams for the transistor amplifiers are given and experimental results for a breadboard model of the multiplier are evaluated. Static accuracies on the order of 1 and 3 per cent and bandwidths of 25 kc and 1.3 kc are obtained for the Hall channel and the magnetic channel, respectively.

12,200 ELECTRONIC DECODING AND CODING FUNCTION GENERATORS by V. B. Smoltov; Automn. Remote Control, Vol. 22, pp. 180-185, Sept. 1961

A digital-analog computer which can be used for functional decoding of digital information and functional coding of analog information is described. The design calculations are based on a piecewise-linear method of approximation. A functional generator operating on the basis of piecewise-linear approximation must operate as a voltage divider. The basic factors considered in the computer design are: the functional characteristic of the generator, the required decoding precision, the source voltage, the output impedance and the load resistance. Design modifications required for a low resistance or alternating load are also considered.

12,201 A MAGNETIC INTEGRATOR FOR THE PERCEPTRON PROGRAM by J. K. Hawkins and C. J. Munsey (Aeronutronic); U.S. Gov. Res. Rep., Vol. 36, p. S-46(A), July 20, 1961 PB 150 142

The construction and successful operation of a "learning" machine, employing magnetic integrators as storage for experience data, is discussed. The machine is capable of learning

all possible linear-logic functions of up to four input variables, and some functions of five variables. The machine is constructed along the lines of the association-response portion of the Perceptron system, differing only in detail with respect to growth logic, logical levels, etc. Successful operation of the machine has demonstrated the practicability of constructing Perceptron-type systems using the magnetic integrator component developed. Fabrication costs of the component permit construction of moderately large Perceptron-type systems capable of operating at high learning rates. The configuration and important characteristics of the learning machine and the integrator component are summarized. A brief report on a computer program which can simulate a variety of similar learning machines is included.

12,202 ADAPTIVE SWITCHING CIRCUITS by B. Widrow and M. E. Hoff (Stanford U.); U.S. Gov. Res. Rep., Vol. 35, p. 806(A), June 16, 1961 PB 150 227

An adaptive pattern classification machine (called "Adaline" for adaptive linear) which illustrates adaptive behavior and artificial learning is described. During a training phase, crude geometric patterns are fed to the machine by setting the toggle switches in a 4 x 4 input array. Setting another toggle switch tells the machine whether the desired output for the particular input pattern is +1 or -1. All input patterns are classified into two categories. The system learns from each pattern and accordingly experiences a design change. After training, the machine can be used to classify the original patterns and noisy (distorted) versions of these patterns. At present the purely mechanical adaption process is accomplished by manual potentiometer-setting. A means of automating this process which makes use of multi-aperture ferromagnetic devices is being developed.

Electroluminescent Panels for Data Display - See 12,005

POWER APPLICATIONS

Thermoelectric Power Generators - See 12,010 and 12,011

12,203 THE DESIGN OF REGULATED, MINIATURE HIGH-VOLTAGE DC POWER SUPPLIES FOR SATELLITE AND DEEP SPACE PROBE APPLICATIONS by J. B. Minter (Components); IRE Intl. Conv. Rec., Vol. 9, Part 9, pp. 79-86, Mar. 1961

Small high-voltage dc-to-dc power converters which employ a closed-loop servo control system deriving primary reference from a pair of stable Zener diodes in a bridge circuit are described. A special circuit arrangement which reduces by more than an order of magnitude the bleeder current usually required to stabilize the relative operating potentials of multiplier phototubes and still provides linear anode current over a wide range is described. Supplies have been built which operate from 3- to 32-volts input and 300- to 4000-volts output. Short-term output stabilities of 0.1 per cent with respect to both input and moderate load changes have been attained. A stability of 1 per cent can be maintained over a temperature range of -10° to +60°C, or the temperature compensation can be adjusted to correct for variation of multiplier phototube gains vs temperature. Over-all efficiencies of 40 to 50 per cent have been obtained at power output levels of 50 to 100 mw.

12,204 STUDY AND DEVELOPMENT OF TRANSISTORIZED MODULAR POWER CONVERTERS by F. L. Raposa (United Aircraft); U.S. Gov. Res. Rep., Vol. 36, p. 16(A), Oct. 20, 1961

Investigations in the field of transistorized power supplies are discussed. The topics considered are: 1) methods of voltage regulation, 2) methods of voltage sensing, 3) methods of obtaining multiple output voltages, and 4) methods of obtaining multiple output voltage levels. Several approaches to each topic have been attempted with emphasis on the advantages and disadvantages of the modular concept. A typical modular system which illustrates the flexibility of the modular concept is presented. A breakdown of the concept results in 19 basic modules to cover 2 input voltage ranges, delivering any power input up to 300 watts at 10 different output voltages, the output being either regulated or nonregulated.

12,205 PRACTICAL APPLICATION OF SILICON DIODES TO POWER SUPPLIES USED IN SCIENTIFIC APPARATUS by F. E. Dickey (GE Res. Labs.); Solid State J., Vol. 2, pp. 29-32, July 1961

The use of Si junction diodes in power supplies for scientific apparatus is discussed. The advantages (long life, efficiency and cool running) over tube rectifiers are noted. Regulation curves are used to compare diode performance with 5Y3 and 5U4 tubes.

12,206 ZENER DIODES AND THEIR APPLICATION IN REFERENCE UNITS by J. Banga (Electroflo Meters); Brit. Commun. Electronics, Vol. 8, pp. 760-764, Oct. 1961

Basic characteristics of Zener diodes and some of the limiting factors controlling their use in reference units are described. Chemical structure in semiconductors, basic theory of p-n junctions and the breakdown effect in Si are discussed. Results of long term stability tests indicate that there is a considerable time (greater than 5000 hours) before reaching absolutely stable operation. The positive drift amounts to 0.1 - 0.2 per cent in breakdown voltage; this is due to oxide contaminations. Design considerations for a mains operated reference unit are given in which the diode is placed into a high resistance balanced bridge. The solid state standard cell is useful in automation and measurement techniques, where size, simplicity, continuous operation and utmost reliability are primary considerations.

dc to ac Silicon Controlled Rectifier Power Converters - See 11,944

12,207 SEMICONDUCTOR INVERTER WITH CAPACITIVE LOAD MEANS by J. L. Jensen (Minn.-Honeywell); U.S. Pat. 3,004,226, Issued Oct. 10, 1961

A semiconductor inverter which provides for a decrease in current drawn from the source when the output load current demand decreases is described. The device employs two transistors which, by alternately conducting through a primary of a step up transformer, induce a high voltage alternating potential across the secondary. This voltage is rectified by a full wave semiconductor diode circuit and applied to a load or utilizing device. A saturable reactor is connected so as to switch conduction between the two transistors. Losses of the inverter apparatus are minimized. It is suitable for supplying current to a capacitive load.

12,208 REPLACING SINE WAVE SOURCES WITH SOLID-STATE INVERTERS by D. Levy (Daven); Electronics, Vol. 34,

POWER APPLICATIONS (Cont'd)

pp. 80-83, June 30, 1961

A way of overcoming difficulties in the application of solid-state inverters to electronic equipment designed for sinusoidal input is discussed. The inverter output is commonly a square wave where the peak, rms and rectified average voltages are equal. Two methods for varying the peak of average to rms ratio are mentioned: 1) a series magnetic amplifier, and 2) a saturable reactor using a magnetic core with a square loop characteristic. The latter method is discussed in detail and suitable core materials are listed. A wave train is obtained consisting of equal positive and negative pulses separated by a phase angle ϕ. The magnitude of this angle is made variable and hence the peak or average to rms ratios. Substitution of the modified square wave for a sine wave is investigated with respect to ripple factor, harmonic content and conversion efficiency.

CONTROL APPLICATIONS

12,209 TECHNIQUES OF TIME-DOMAIN SYNTHESIS FOR CONTROL SYSTEMS by C. W. Steeg (MIT); U.S. Gov. Res. Rep., Vol. 36, p. S-33(A), Aug. 20, 1961 PB 156 467 $9.60

Time-domain synthesis procedures that are not only simpler than many other control-system design procedures but also achieve better performance for many systems are presented. A basic component in the control system synthesized is an extrapolator, or predictor, that operates to determine the value of a signal at some future time. The design of these extrapolators is explained in terms of a simplified linear analytical prediction theory, which attempts to bridge an apparent gap in technical literature. The report assists in explaining in simple terms both the criteria significant in the design of control systems synthesized by time-domain methods and a definite analytical procedure for the determination of the controller properties necessary for the specified over-all system performance.

12,210 HALL-EFFECT CONTROL ELEMENT WITH UTILIZATION CIRCUIT by H. Weiss (Siemens-Schuckertwerke); U. S. Pat. 2,988,650, Issued June 13, 1961

A semiconductor device which provides a Hall voltage output sufficient to drive high-power-input apparatus is described. Semiconductors equipped with Hall electrodes are placed between the poles of an electromagnet. The Hall electrode pairs are connected in voltage-cumulative relation or in mutually insulated electric circuits that are inductively linked with a magnetizable core. Application of a magnetic field produces a voltage difference between the Hall electrodes proportional to current flow and strength and orientation of the magnetic field. Using InAs with 1.2 amp current flow and a 10,000 gauss field, a Hall voltage of 1.2 v and a power output of 100 mw per semiconductor has been obtained. Efficiency is above 20 per cent.

Hall Effect Control Components - See 12,000

12,211 SAFER INTERLOCKING BY SOLID STATE RELAYS by F. H. Laishley and M. H. Roberts (J. L. Res. Ctr.); Brit. Commun. Electronics, Vol. 8, pp. 514-517, July 1961

Completely fail-safe interlocking control of machinery or signals by a new way of using transistors and ferrite cores in logic units to replace relays is described. The logic circuit design is such that no output is obtained in the event of any component failures. Signals are of the ON-OFF type. The switching units must be continuously oscillated between two states to produce an output signal. Units requiring only initiation signals will not respond to a single pulse, but require a pulse train of a predetermined length. The logic functions employed are AND, OR and CHANGEOVER (a composite NOT/AND function which enables the NOT function to be carried out safely). The CHANGEOVER function is analogous to the changeover contacts of a relay. The latching circuits de-energize if the power supply is interrupted. An amplifier between the logic units and the load converts the supply energy into the required form when the load is to be energized. Failure of the converter prevents energizing of the load. A multivibrator is used as a master oscillator to clock the system.

Relay Oscillators - See 12,101 and 12,105

12,212 A DIGITAL START-UP CONTROL UNIT FOR NUCLEAR REACTORS by J. D. Schmidt, B. K. Eriksen and W. Peil (GE); IRE Intl. Conv. Rec., Vol. 9, Part 9, pp. 15-30, Mar. 1961

The design and development of a nuclear reactor start-up control and display unit utilizing transistors in a switching mode are described. The unit operates with input pulses that vary in amplitude from 2.5 to 50 mv and pulses spaced as little as 1 μsec apart. The reactor level is obtained as the output of a binary counter and the period is computed using several binary counters that perform a time-modulation division operation. Statistical smoothing of the period computation is obtained by employing a memory unit in the time-modulation computation. Relay driver outputs are provided and both the level and period are displayed with decimal readout indicators.

12,213 A NUCLEAR REACTOR REGULATING ROD POSITION INDICATOR by R. I. Little (Phillips Petrol.); IRE Intl. Conv. Rec., Vol. 9, Part 9, pp. 8-14, Mar. 1961

The problems of regulating rod position indication in the Measurement Facility of the National Reactor Testing Station are discussed. A system using a high resolution shaft angle digitizer and solid state digital and analog circuitry is described. The system assures high over-all accuracy and allows precision repositioning. Block diagrams and circuit descriptions are presented.

INSTRUMENTATION

Hall Effect Instrumentation Components - See 12,000

12,214 MULTIPHASE WATTMETERS BASED ON THE MAGNETO-RESISTANCE EFFECT OF SEMICONDUCTORS by M. J. O. Strutt (Swiss Fedl. Inst. Tech.) and S. F. Sun (Inst. Tech. Hochsch., Stuttgart); IRE Trans., Vol. I-10, pp. 44-49, June 1961

The application of magnetoresistive elements to the measurement of both real and reactive power is described. Within a

certain range around a properly chosen magnetic bias flux density the change of resistance of the magnetoresistive element is nearly proportional to the change of flux density. By making the flux density proportional to either the alternating phase current or to the phase voltage while the current through the magneto-resistive element is proportional to the phase voltage or phase current, respectively, real or reactive power may be measured. Temperature compensation is discussed as is the use of this technique in multiphase circuits. Corbino disks may be used as the element.

12,215 DEVELOPMENT OF TRANSISTORIZED AND MODERNIZED INTERFERENCE MEASURING SET AN/PRM-1 (XN-2) (Stoddart Aircraft Radio); U.S. Gov. Res. Rep., Vol. 36, p. 101(A), Sept. 5, 1961 AD 258 396

A description of a transistorized interference measuring set AN/PRM-1 (XN-2) is presented. Completely redesigned transistorized circuits were developed for the RF, IF, detector and voltmeter amplifier systems. Evaluation tests were performed and the general and factual data resulting from these tests are described. Also included are studies on the various aspects of the transistorized circuitry. Recommendations are given for improvement in the existing transistorized circuitry based upon the experience gained in the test performance.

12,216 APPLICATION OF THE HALL EFFECT TO BASIC MEASUREMENTS by N. P. Milligan and R. W. Crawford (Ohio Semicon.); U.S. Gov. Res. Rep., Vol. 36, p. 128(A), July 5, 1961 AD 255 070

The practicability of utilizing the Hall effect for measuring the current in a conductor or the microwave power in a waveguide is discussed. A dc Hall effect milliammeter with range of 5-0-5 ma, 50-0-50 ma and 500-0-500 ma is described. Methods of overcoming such problems as drift, ohmic unbalance in the Hall probe, and spurious magnetic fields are discussed. The basic theory relating to the use of the Hall effect as a microwave power meter is reviewed. Details of the experimental data taken with InAs and Ge probes are presented. The presence of certain high spurious voltages are thought to be due to the Seebeck effect. Data showing that a power meter for specific load conditions can be constructed are shown.

12,217 HYSTERESIS CURVE TRACER FOR MAGNETIC THIN-FILMS by T. F. Bryzinski and D. R. Sahba (Genl. Dynamics); IRE Intl. Conv. Rec., Vol. 9, Part 9, pp. 249-257, Mar. 1961

A hysteresis curve tracer for thin film specimens is discussed. The sensing coil will accommodate films 0.5 to 1.5 cm in diameter and 500 to 20,000 A thick. The maximum size of the substrate is 18 mm square and 0.1 to 1 mm thick. The design of the sensing coils is discussed as are the electronic deflection circuits used in the display.

12,218 METASTABLE HELIUM SENSITIVE MAGNETOMETER by J. A. Rice, Jr. (Texas Instr.); IRE Intl. Conv. Rec., Vol. 9, Part 9, pp. 244-248, Mar. 1961

The use of optical pumping in the Zeeman resonance of metastable helium and the properties of the resonance signal obtained are discussed. A PbS detector senses the resonance signal, a modulated 1 μ emission from a helium discharge. The slope of the resonance is used in a frequency control feedback circuit to construct a magnetometer whose external magnetic field strength vs frequency relation is linear. A prototype instrument which is small, light and insensitive to probe orientation is described.

12,219 THRESHOLD SENSITIVITY OF RADIATION RECEIVERS by E. S. Ratner; Optics and Spectrosc., Vol. 9, pp. 52-55, July 1960

The relationship of the sensitivity threshold of radiation receivers, as determined by the fluctuations in the effectively absorbed quanta, to the magnitude of the steady background and certain properties of the receiver-amplifier-indicator system is considered.

Piezomagnetic Stress Transducer - See 12,019

12,220 DEVELOPMENT OF A MINIATURE PRESSURE TRANSDUCER FOR APPLICATION TO AIRFOIL STUDIES IN THE SHOCK TUBE by J. R. Ruetenik (MIT); U.S. Gov. Res. Rep., Vol. 36, pp. S9-S10, Oct. 1961

A miniature BaTi pressure transducer is described. The device developed to measure the pressure on an airfoil in a shock tube is 1/8 in thick and produces a 0.1 v/psi signal. Problems of charge leakage were solved. The strain, vibration and thermal sensitivities were considerably reduced.

Ultrasonic Transducers - See 12,049

Four Channel Scintillation Counter and Data Reduction System See 12,159

12,221 USE OF ENTRANCE HODOSCOPE FOR PARTICLE IDENTIFICATION IN VERY-HIGH-ENERGY BUBBLE CHAMBER EXPERIMENTS by W. Selove, H. Brody and E. Leboy (U. Pennsylvania); IRE Intl. Conv. Rec., Vol. 9, Part 9, pp. 97-105, Mar. 1961

A hodoscope system that will identify 20 particles entering a bubble chamber during a 100 μsec interval is described. Transistorized position coding and particle identity circuitry is used.

12,222 A DIGITAL DATA HANDLER FOR PULSED PARTICLE ACCELERATORS by W. A. Higgenbotham and D. W. Potter (Brookhaven Natl. Lab.); IRE Intl. Conv. Rec., Vol. 9, Part 9, pp. 67-74, Mar. 1961

A digital data handler for storing information in a magnetic core memory during the pulse of a synchrotron and transferring it to a slow memory during the dead time is discussed. Digital

measurements of trajectory, pulse height, etc. are stored in the fast memory which can store 32 words of 96 bits. The information is then transferred to 1-in magnetic tape. Details of the transistorized circuit are presented.

12,223 A GOLD-SILICON SURFACE-BARRIER PROTON RANGE TELESCOPE by R. Takaki, M. Perkins and A. Tuzzolino (U. Chicago); IRE Trans., Vol. NS-8, pp. 64-72, Jan. 1961

A proton range telescope formed by using two 0.004 in Au-Si wafers is described. Requirements for space vehicle applications demanding detecting units of limited weight, size and power could be satisfied. Information concerning the proton flux lying in the energy intervals from ≈ 0.5 to 5 Mev and 5 to 10 Mev is provided by the apparatus without the use of pulse-height analysis. This principle can be extended to additional energy intervals.

12,224 A GENERAL PURPOSE, AUTOMATIC TRANSISTORIZED SCALER by A. W. Pryor and A. C. Svenson (Austl. AEC); Proc. IRE Austl., Vol. 22, pp. 629-635, Oct. 1961

The design and performance of a completely transistorized, general purpose, automatic scaler are described. The incoming pulses and standard time pulses are counted on two rows of five Dekatrons. Preset times range from 1 sec to 1,000 min. High input rates may be counted by inserting a fast non-indicating decade. Standard plug-in input units enable the scaler to be used for a wide range of routine nuclear countings and it may easily be adapted for many special problems.

Radiation Counting Amplifiers - See 12,081

Dosimetry by Luminescence Degradation in Organics - See 11,903

12,225 SOME RECENT DEVELOPMENTS IN RADIOPHOTOLUMINESCENT DOSIMETRY, INCLUDING TEST RESULTS by W. C. Bryan and W. P. Schaus (Kirkland AFB); U.S. Gov. Res. Rep., Vol. 36, pp. 94-95(A), July 5, 1961 AD 255 899

A new Navy-sponsored model of the Detector, Radiac DT-60/PD and an experimental Air Force modification of the Computer-Indicator, CP-95A/PD are reported. The results of testing the new dosimeter and modification of the computer-indicator are reported and the calibration procedures are discussed. Some comments are made on the compatibility of old and new models of the dosimeter with the CP-95A/PD, and on continuing developments.

Frequency Standard Using Masers - See 12,044

12,226 FOUR PHASE CLOCK by H. A. Seidman (Genl. Precision Lab.); U.S. Pat. 3,004,174, Issued Oct. 10, 1961

A four phase clock circuit which provides output signals corresponding in time with the peaks and zero voltage levels of a varying voltage is described. An alternating voltage is applied to an input terminal to which are connected a positive peak detector, a multiar circuit arranged to produce a pulse when a negative going signal passes the zero voltage level, a negative peak detector, and another multiar which indicates the zero voltage level of a positive going voltage. The four circuits are all connected to an OR which provides the clock output. A description of the operation of the basic peak detector and multiar circuits is given. In another arrangement the alternating voltage is applied to a full wave rectifier which permits the use of only one peak detector and one multiar while providing the four phase clock output.

12,227 INDUSTRIAL FLUOROSCOPIC INSPECTION BY ELECTROLUMINESCENT X-RAY CONVERTERS by D. K. Wilburn (Detroit Arsenal); Electronics, Vol. 34, pp. 56-58, Sept. 15, 1961

Electroluminescent X-ray converters which give higher brightness than conventional fluorescent screens are described. Brightness is increased by several orders of magnitude, together with improved resolution and contrast, at operating energies in the 150 to 500 Kvp X-ray range. Physical construction of the basic converter is given including a schematic of the converter and its power supply, using interdigitated electrodes for erasing latent images. In the electroluminescent X-ray intensifier, a stratum of photoconductive CdS is sandwiched between the e-l layer and the top electrode, while an opaque film over the e-l layer eliminates excitation from visible light. Photoconductive material is non-conducting in the dark but conducts when exposed to X-rays. When conducting, the photoconductor applies a voltage to the e-l layer, which in turn emits visible light. Another important property of the photoconductor is its ability to absorb X-ray photons. The converters are useful in medical therapy; in industry they can be used as radio-graphic penetrameters, for examination of hermetically sealed devices and in other forms of non-destructive testing.

12,228 NEW CONCEPTS IN DETECTING WEAK ELECTROMAGNETIC SIGNALS by J. Q. Burgess (Ohio State U.); Electronics, Vol. 34, pp. 49-55, Sept. 15, 1961

A general survey of detection techniques, including biological techniques and detector sensitivities, is presented. Specialized detectors developed by plants and animals, and the negative resistance properties of biological nerve fibers are cited. The problem of detection is treated as one of sensing information to be presented to the brain. A chart which compares known detectors with known limits of detection is given. The weakest

signal that can be detected has an energy of one quanta. Scintillation counters, for the X-ray band, are close to the limit of sensitivity. When over-all systems are involved the maximum sensitivity both for biologic and man-made detectors seems to be between 10^{-17} and 10^{-18} watt. Over the infrared interval the available detectors are less sensitive than those above and below by as much as several orders of magnitude. Possible techniques of detection explored were: optical Faraday-rotation/paramagnetic-resonance detector, microwave radiation pressure detector, cryogenic bolometer for detecting microwaves, optically pumped atomic resonant devices, secondary emission processes, devices which couple directly to the nerves in the skin and superregenerative methods employing new low-noise devices such as masers, tunnel diodes and parametric amplifiers. The combination of relaxation detection with atomic resonance techniques to provide a sensor for electromagnetic radiation is suggested to approximate the ideal detector in terms of sensitivity, simplicity, selectivity, small size and efficiency.

12,229 PHOTOCELL FIELD COUNTS RANDOM OBJECTS by P. Weston (U. Illinois); Electronics, Vol. 34, pp. 46-47, Sept. 22, 1961

A device that counts randomly arranged objects of various shapes and sizes is described. A retina network is made up of a square array of photoresistors, each connected to a unit lying beneath it in the computing layer. The computing layer is an array of active elements. Each active element is a transistor whose base is dc connected to a resistance summing network. A positive feedback system is employed to constitute a memory trace which, upon input from an interrogation scanner, causes all the units with darkened photocells to be cut off. A summing network is attached to the collectors in adjacent rows of the units; the network feeds an OR circuit to generate output pulses which are then counted. A 400-cell unit outperforms humans in counting irregularly arranged objects. It can count as many as 40 objects in 0.2 seconds. The only requirement for accurate counting is a separation of at least one cell between all objects on the photocell layer of the device.

OTHER APPLICATIONS

Military Applications of Peltier Heat Pumps - See 12,008

Thermoelectric Refrigerators - See 12,009

12,230 THERMOELECTRIC PROBE (Electro-Impulse Laboratory, Inc., 208 River St., Red.Bank, N.J.)

An instrument capable of measuring thermoelectric voltages from 1 microvolt per degree C to 900 microvolts per degree C is announced. The Thermoelectric Probe (Model 1E-4) operates by comparing the thermoelectric voltage of Constantan with respect to copper to that of any metal or semiconductor with respect to copper. Measurements taken are independent of the probe temperature; and of the mass, thermal conductivity, shape, ambient temperature and resistivity of the sample. Accuracy is maintained to within 3 per cent.

12,231 GOLD/PHOSPHORUS AND GOLD/ARSENIC ALLOYS (Alloys Unlimited, Inc., 21-01 43rd Ave., Long Island City 1, N.Y.)

Gold/arsenic and gold/phosphorus alloys with nominally up to 2 per cent arsenic and 0.5 per cent phosphorus are announced. While gold/arsenic alloys are more readily available due to greater ease of fabrication, the gold/phosphorus alloys in these concentration ranges show the best wetting properties to silicon. Both new alloys, however, have superior wetting properties and better doping efficiency levels than gold/antimony, and have the dopant more homogeneously dispersed in the gold. In addition to these materials being supplied clad on a variety of substrates, they are available in foil, washer and disc form supplied to close customer specifications. They are expected to be of interest to transistor, diode and rectifier manufacturers who now use gold/antimony foil or preforms to make N plus ohmic contact.

12,232 ALUMINA ABRASIVE (Geoscience Instruments Corp., 110 Beekman St., New York 38, N.Y.)

The "Corunda" line of electronic grade alumina abrasives for the polishing of Ge, Si and other semiconductors is announced. These fine particle polishing abrasives produce the low micro inch finishes and ultra-high polishes required in critical surface preparation. The powders are produced in particle sizes of 1.0, 0.5 and 0.1 microns (Corunda "C", "A", and "B" respectively), and are also obtainable in aqueous suspensions.

12,233 EPITAXIAL VARACTORS (Sylvania Electric Products, Inc., 730 Third Ave., New York 17, N.Y.)

The D-4200 series of double-ended epitaxial varactors is announced. These varactors feature breakdown voltages from −6 to −120 volts, cutoff frequencies from 10 kMc to 140 kMc (measured at -6 volts), and capacities from 0.2 μμf to 10 μμf. They are expressly designed for use in harmonic generators or modulators and are manufactured to provide a capacitance and voltage breakdown relationship for optimum conversion efficiencies at a specific operating frequency and power level. Power dissipation is up to 2 watts at 25°C, with burnout rated at 2.5 watts. All military environmental requirements for shock, temperature cycling, moisture resistance, and centrifuge are met.

12,234 EPITAXIAL STAR PLANAR TRANSISTORS (Motorola Semiconductor Products, Inc., 5005 East McDowell Rd.,

Phoenix 8, Ariz.)

Epitaxial star planar transistors available in the MM486 series (TO-5 package) and MM511 series (TO-18 package) are announced. These are silicon n-p-n double-diffused transistors of new junction configuration and designed for operation over a range of currents from 100 μa to in excess of 500 ma. Featured is a low leakage current (typically 0.001 μadc), coupled with a typical f_T of 400 Mc which allows these transistors to be used in high speed switching and VHF-UHF amplifiers as well as for dc amplifier applications. They are 100 per cent baked at +300°C, and are rated to a junction temperature of +175°C. Testing is in accordance with MIL-S-19500B.

12,235 TRANSISTOR PARAMETER TEST SET (Dynatran Electronics Corp., 178 Herricks Rd., Mineola, N.Y.)

A transistor parameter test set (Model 1803) designed for the measurement of the small signal parameters of both n-p-n and p-n-p transistors is announced. In addition, collector leakage current (Ico) can be read over a range of values extending from less than five millimicroamperes to one milliampere. Each parameter can be individually pre-set to the desired range by means of front panel switches.

12,236 ELECTRON BEAM VAPOR DEPOSITION UNIT (MRC Manufacturing Corp., Orangeburg, N.Y.)

A self-contained, desk-sized unit (Model EVD-96) for high-vacuum vapor deposition of thin films of high temperature materials is announced. The electron beam heating source consists of an annular gun and focusing shields. The vacuum chamber is machined from a single aluminum forging which is then highly polished on all interior surfaces. A 4" fractionating-type diffusion pump rapidly pumps down for operation in the 10^{-6} to 10^{-7} TORR range. Temperatures in excess of 3600°C are provided by a high reactance, high voltage power supply. A heated substrate holder with modular power supply, and indexing rotary substrate holder for multi-sample depositions are available as optional equipment.

12,237 PRECISION DICE MOUNTER (Kulicke and Soffa Manufacturing Co., 401 N. Broad St., Philadelphia 8, Pa.)

The Model 600B dice mounter is announced. This precision instrument provides exact and positive control of positioning together with full regulation of preheat temperature, temperature rise, and bonding heat. The rates of temperature rise and bonding time are each controlled by separate timers. A metered atmosphere cap provides fluxless mounting and, on the completion of bonding, the dice is automatically cooled by a flow of gas. Optional equipment includes a footswitch controlled vibrator and a microscope for continuous focus on work area.

12,238 WATER DEIONIZER (Penfield Manufacturing Co., Inc., 19 High School Ave., Meriden, Conn.)

A monobed pressure cartridge deionizer (Model PM-8) for application in the manufacture of semiconductor devices is announced. It is capable of water purification to 18-22 megohms. Especially valuable wherever contamination of plant water supply threatens product quality, this point-of-use unit permits flows up to 50 GPH at less than 4 lbs pressure drop with 100 per cent exchange efficiency. Built entirely of plastic to eliminate metallic contamination, the clear sump additionally allows visual inspection of exchange resins. The unit may also be used as cation or anion exchanger, water softener, activated carbon filter, oxygen remover or organic scavenger.

12,239 PHASE SWITCH (Tricónix, Inc., Bear Hill, Waltham 54, Mass.)

A solid state device (Phase Switch, Model PS-1) to provide an output waveform which is in phase with the input waveform for positive control voltage, and out of phase for negative control voltage is announced. The unit is broadband and may be utilized in a wide variety of phase modulation, coding and interferometer applications. Specifications include: frequency range, 15 to 45 Mc; impedance level, 50 ohms, BNC; insertion loss, 6 db; amplitude unbalance, less than 0.2 db; and switch drive, 10 volts into 500 ohms. Total weight is 3 ounces.

12,240 TRANSFORMER COUPLED CHOPPER (Solid State Electronics Co., 15321 Rayen St., Sepulveda, Calif.)

The Model 65 transistorized plug-in chopper is announced. This solidly encapsuled unit is designed to alternately connect and disconnect a load from a signal source, or for use as a demodulator to convert an ac signal to dc. It can be driven over a frequency range of 270 cps to 30 kc and through a dynamic range of a fraction of a millivolt to 5 volts. Its built-in transformer-coupled isolating drive network permits it to be driven from a 400 cycle power line or from a drive source common to the dc voltage being chopped. It can be plugged into any standard 7-pin miniature tube socket.

12,241 POWER SUPPLY (Kepco. Inc., 131-38 Sanford Ave., Flushing 52, N.Y.)

The Model ABC 7.5-2 power supply is announced. This unit delivers 0-7.5 volts at 2 amperes with 0.05 per cent regulation and stability. Input power is 105-125 volts, 50-440 cps. Adjustable wide range current limiting makes this unit suited to semiconductor component or circuit evaluation. With the ability to program at constant current, it may also be applied to energizing tungsten filaments or magnets. Accessible control terminals enable remote error sensing, proportional control of multiple power units, and series and parallel connections. A unique error sensing circuit provides full voltage range regulation and programming.

12,242 LIGHTING POWER SUPPLY (Tenney Engineering, Inc., 1090 Springfield Rd., Union, N.J.)

The Model SP-300 "Solar-Pak" dc output power supply is announced. This 300 watt unit is one of a series designed to supply power for xenon, mercury-xenon, or carbon arc lamps. The lamps are used to simulate solar radiation in environmental testing and to provide high intensity lighting for motion picture and other applications. Featuring a solid state static system with Si and Se rectifiers, the unit has no rotating components that might fail mechanically. Other features include automatic and semi-automatic controls, timed control circuits, low power input and overload protection.

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